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Storage Industry Opportunities Overview & Analysis

2003/7/29

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World leader in ATA RAID Technology

RAID Serial ATA

PROMISE® TECHNOLOGY, INC.

喬鼎資訊股份有限公司

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1. The emerging background of storage industry

Internet brings new e commerce storage need

As the global e-commerce is booming, the amount of 24 hours available online access data has grown several times without a sign of stop. The emergence of internet has brought storage market new opportunity of massive data transfer.

Multimedia application spurs the growth of data speed and capacity

As more and more computer software and programs and larger and larger the hard discs capacity are available in the market, multimedia technology has changed its face continuously and been in rapid growth. Therefore, the application of information products has brought market demand of high capacity storage: video, special effect of music and data access drive larger storage capacity; besides, to reach smoother screen and better resolution in 3D games, large data flow rate will require not only a faster operation speed and transmission but also an effective and value-added processing on the digital data.

Content of the digital data is booming incrementally

The coming of digital era: Analog data storage has been gradually replaced by digital data storage, and the derivative application market covers a wide range in the multimedia
related fields:

- Digital image processing (computer aided drawing, 3D animation, etc.)
- Digital music (MIDI, etc.)
- Digital video (AVI, VCD, DVD, etc.)
- Digital video conference (DVR Digital Surveillance Recorder, VOD)
- Others (fixed data storage such as medical X ray, E-mail file attachment, image and picture, multimedia data and satellite image, etc.)

After stepping into e-oriented management, storage management draws more attention

KM (Knowledge Management), ERP (Enterprise Resource Management), CRM (Customer relationship management), such expenses for an enterprise in the related information system of knowledge management have increased a lot on the demand of data storage. Enterprise now has now emphasized more and more on the demand of knowledge management and in-time data backup, and data storage and management topics have now become some of the most important IP topics.

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Market trend

Dataquest pointed out that storage system has occupied overall enterprise purchase value from 43% in 1998 to 80% in 2002, this shows that a strong demand for enterprise storage will thrive in the future.

IDC addressed that the global storage capacity in 2002 has reached 0.5 million TB, it is expected to reach 2.5 millions TB in 2006, that is, a five times growth is expected to be seen in the next five years; in other words, the global storage market value is going to rise from 60.6 billions UD dollars in 2002 to 70.6 billions US dollars in 2004. ”RAID disk array” , one of the core technologies in storage industry has a compound annual growth rate (2001-2005) of even 11-13%, as compared to 0.11% in the PC market, 4.13% in the notebook PC market, 9.18% in the server market, RAID Redundant Array of Independent Disk (hereafter abbreviated as RAID) has a much higher market growth rate than other IP markets.

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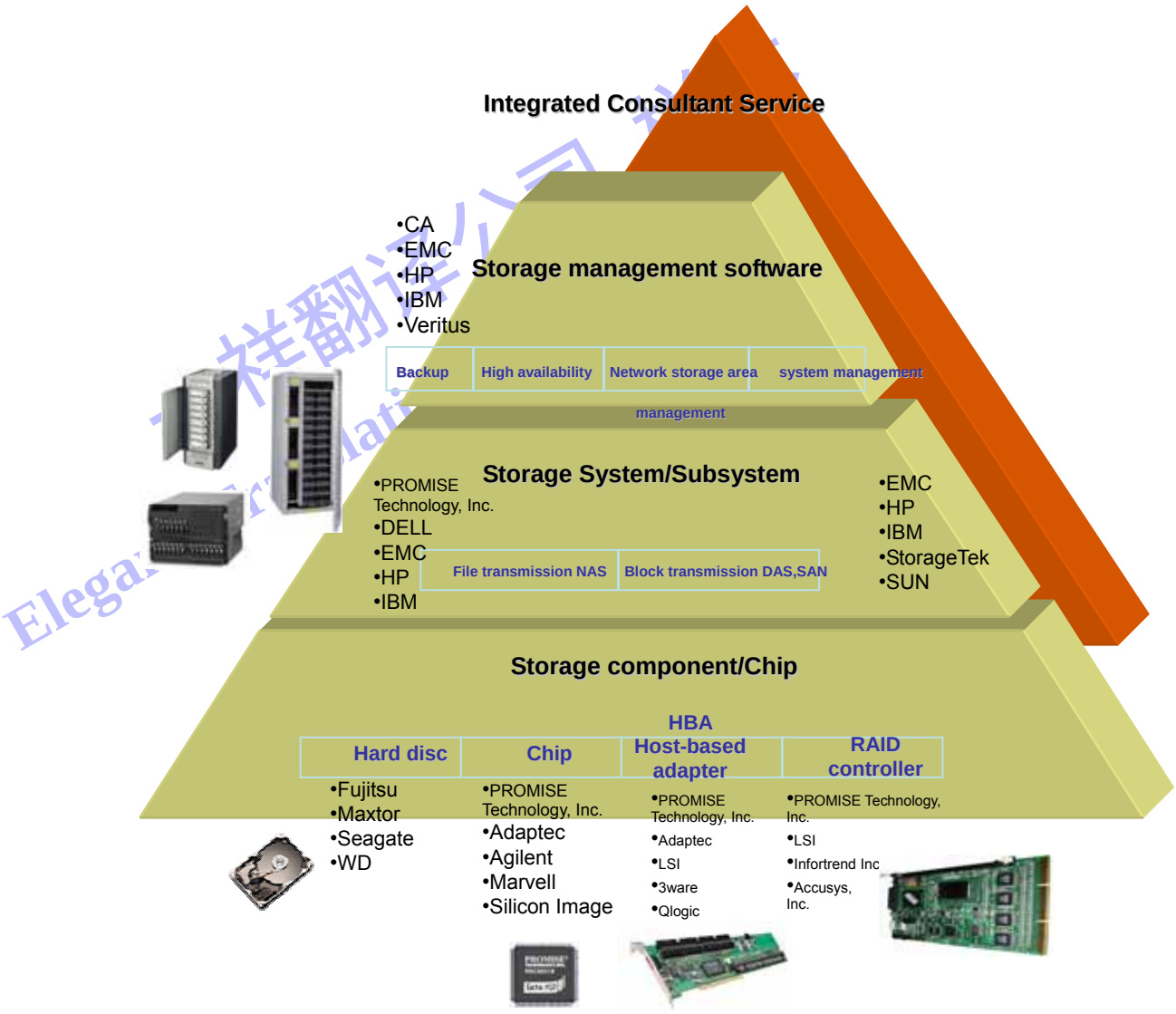
1. Overview of global storage industry



When we talk about the related products and scope of “storage”, storage media should include more than tens or products such as: disk, magnetic tape, CD compact disc, DVD, MO, optical fiber storage system, network storage system, disk array storage system…, etc.; these products can be divided into optical storage and magnetic storage components and equipments, etc. Since most of the current desktop computers or server systems are based on hard disc as the major media for massive storage, and the enterprise customer tends to use RAID disk array as storage system for online storage and redundant, however, in order to distinguish and focus our investigated topic, we will target at storage industry (Disk Storage System) based on the application of hard disc.

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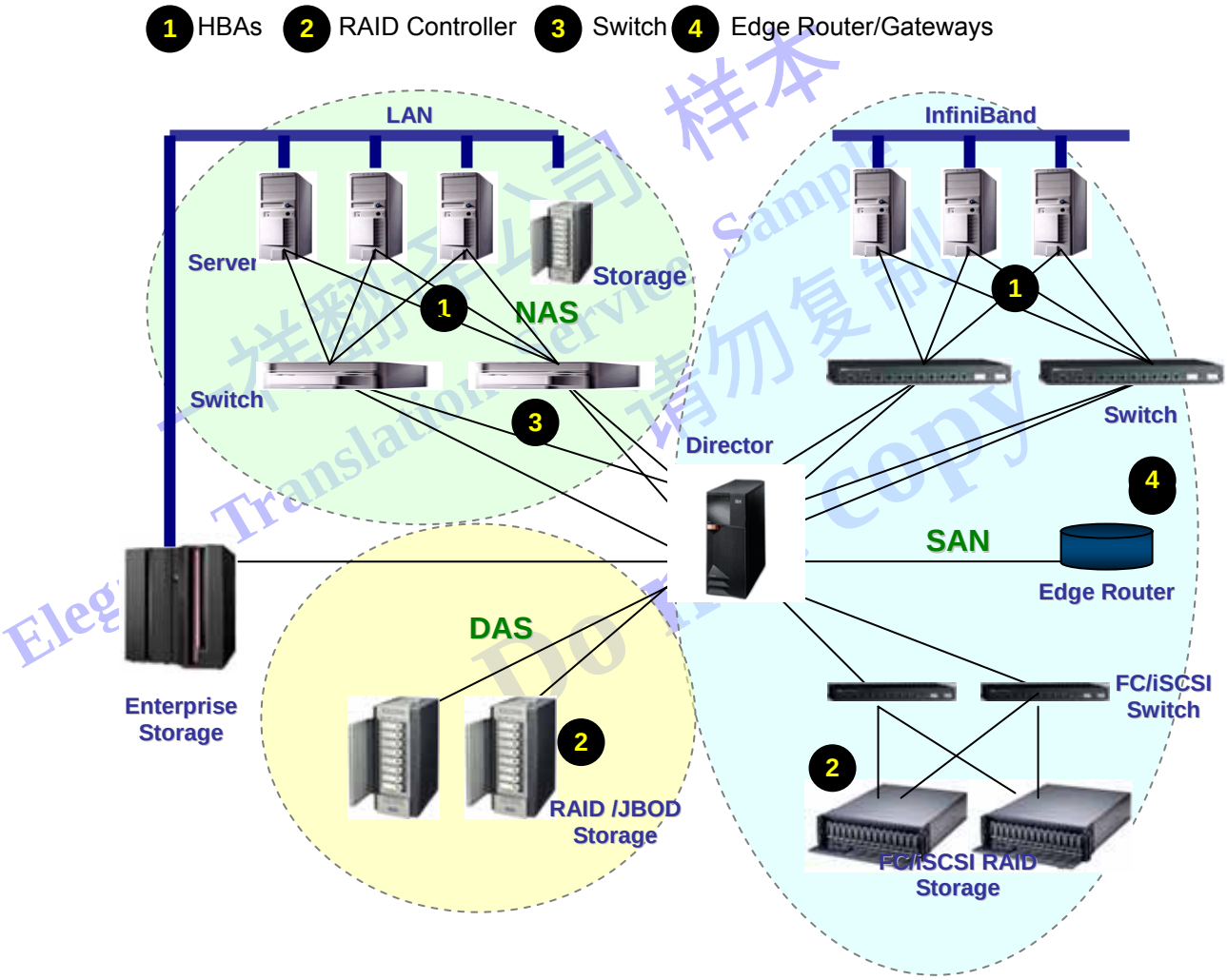
2.1 Over view of storage architecture application

Application of storage component in storage industry



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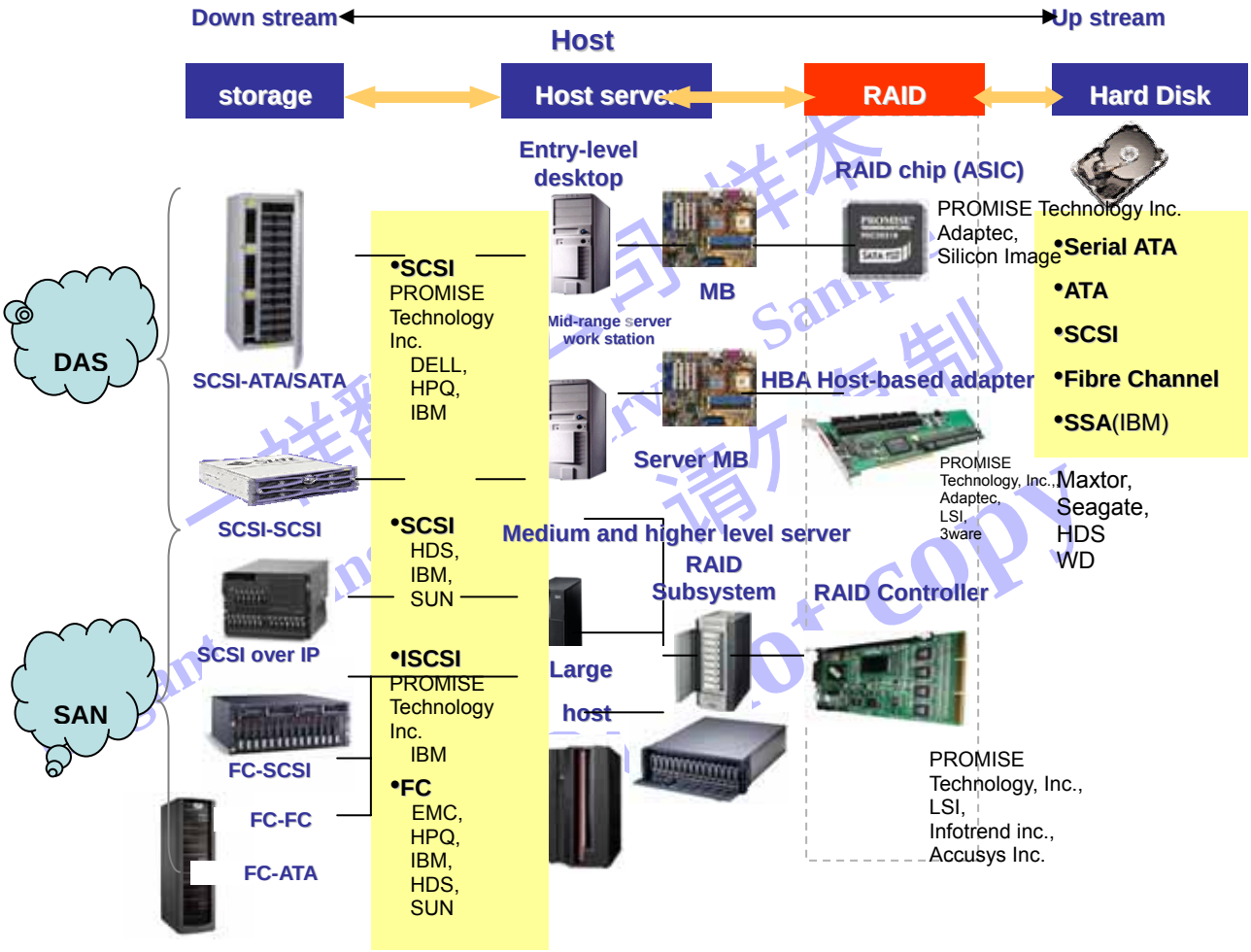
2.2 Industry correlation chart from storage component to storage system



In the whole storage industry, RAID is one of the most important core technologies, RAID disk array controller card/device connects at one end to Host and at another end to hard disc. Therefore, technologies such as the interface of RAID disk array controller card, all kinds of support specs, related technologies, hard disc and the host are all interrelated to each other. Currently, the mainstream interfaces between host and hard disc are two types such as ATA (also known as IDE) and SCSI, however, for FC optical fiber interface, due to its high cost, has been mostly used in the network storage system of large enterprise. Currently, most consumer PCs (desktop PCs) adopt ATA interface, but the servers in mid-sized enterprise adopt SCSI interface.

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2.3 Input/Output (I/O) Protocol

The so-called I/O (Input/Output) means data input and output action, and Protocol is used to define the common connection “standard” for input and output. The whole storage system architecture can be mainly divided into two parts, one is the transfer interface in between the computer server mainframe (Host) and RAID Controller end (as in circle 1), another is the transfer interface at the in between the storage device and the hard disc end (as in circle 2). Currently, the mainstream outer transfer interface between the host and storage system is mainly based on SCSI and FC, and the controller interface in between storage device and hard disc is mainly based on ATA, SCSI. However, along with the launch of Serial ATA new interface into the market, with its more spec advantages than original ATA, it is expected to replace the original ATA market within three years, and its growth within five years is expected to exceed and penetrate into SCSI market, it is expected to enter the higher level enterprise server application market. Due to the higher cost of Fibre interface product, it is used currently only in some large enterprises.

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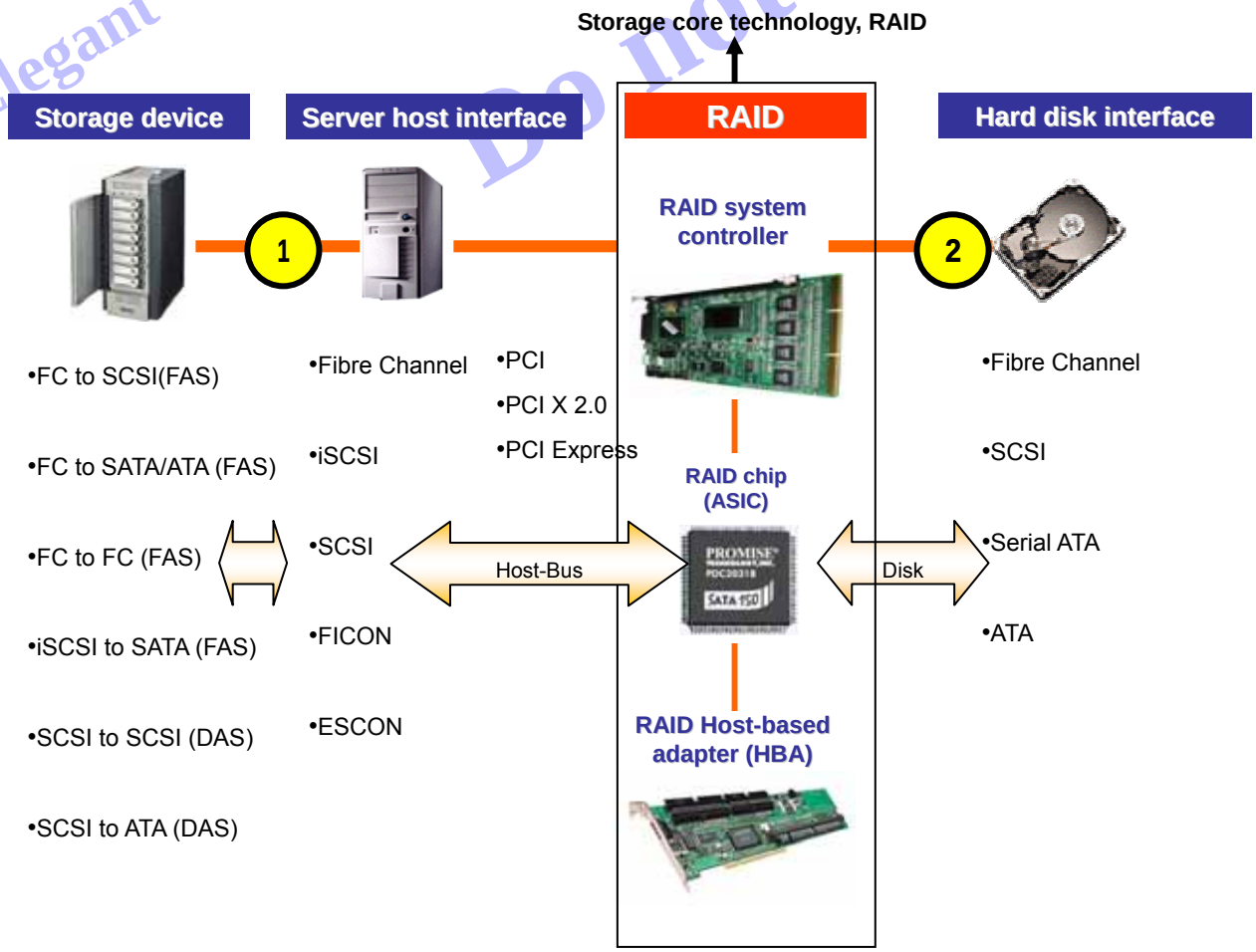

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2.4 Main supplier list in the storage market

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2. Key sub-industries of the storage industry

3.1 Sotrage main components

Storage component plays an important role in the whole storage market. Since it has certain technological entrance barrier, it belongs to technology-intensive industry, competitive yet cooperative relationship is maintained among the suppliers; meanwhile, technological standard making is shared among the suppliers under the premise of mutual interests. Most of the suppliers focus on the market with more mature IT technology and with the power to lead the industry spec standard, for example, the USA market. Since the related components of transfer protocol is still at a continuous technology improvement and innovation stage, however, other major hardware components such as CPU, ASIC chip applied in the storage, hard disc and adapter card, etc. have their functions become stronger but price lower, the market predicts that there is going to be a reshuffle in the storage industry due to the revolution in these key components: the giant brand name enterprises would have to face a difficult situation of IT budget constriction and more and more competitive and saturated high level enterprise-oriented storage product, therefore, they will have to turn their market to the medium and small size enterprise and in turn their product from high level to medium and low level market. In other words, Enterprise will spend less and less on the storage buildup cost, this is like to spend at a cost of 1.6 normal sedan to buy 2.0 limousine.

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Storage component can be divided into four types:

1. Semiconductor device:
   It can be divided into IP Storage, InfiniBand, TCP Offload, Serial ATA(SATA), etc. Interface adapter or chip.
2. Disk:
   Tape or hard disc, hard disc can have interfaces such as: ATA, SATA, SCSI, SAS, FC.
3. Host-based adapter (HBA):
   It is an adapter installed at the host to provide redundant function to system RAID disk array, good data I/O performance and more effective control on hard disc, it is an adapter in between Host and hard disc (or other storage media). It can be divided into SATA/ATA, SCSI and HBA of FC.
4. RAID controller:
   It is a disk array controller installed in the storage system, it mainly controls data operation of RAID and control the storage device formed by several hard discs.

3.1.1 Semiconductor devices

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1. Semiconductor device can be briefly divided into three major application attributes:

   1.1 Transfer interface protocol:

   - Stepping into Gigabit Serial transmission era. The traditional Parallel bus has reached practical application bottleneck, it can't be pushed to higher transmission speed, therefore, the design of all storage components has gradually been changed to Serial transfer. Currently, the Serial transfer used in storage device mainly include: Serial ATA, IEEE 1394, FC, SSA (IBM spec), the next generation Ultra 320 of SCSI is going to be developed in to SAS (Serial Attached SCSI) serial interface; in the bus aspect, Serial PCI Express interface promoted by Intel is going to be launched soon.
   - Fabric-Attached Storage interface has become a trend. Currently, FC is still the major Fabric-Attached Storage technology applied under the SAN architecture, it includes two protocols based on two optical interfaces such as: FCIP and iFCP. As compared to FC, the later version iSCSI, along with its low price of only 1/2~1/3 that of FC and its competitive advantage inherited from Ethernet, has been seen as a key technology to speed up Fabric-Attached Storage.

   1.2 API (Smart application processor):

   - Including virtualization, safety, QoS (Quality-of-Service), etc. Silicon processor.

   1.3 TOE (TCP/IP offload engine):

   - It can be divided into software and hardware (chip) type TOE, it is the speedup processor of the internet packet of IP Storage, its main function is to share the workload of the server so that server can put its attention on executing other application functions and achieving a speed of over Gbps.

3.1.2 Hard Disk

RAID is in charge of controlling the data I/O in between hard disc and host, and hard disc takes charge the data storage capacity, Therefore, the future spec and technology trend in hard disc has become an important index which affects industry development. Hard disc mainly includes a disc, motor, access arm, read/write head, controller chip, transmission interface port, power supply port, etc., the major transmission interface includes ATA, SATA, SCSI, FC, wherein ATA almost occupies a high global market share of 90% in the hard disc market, it is almost used for the PC market. However, SCSI is used mostly in the enterprise customer, due to its high cost, FC interface is used only for high level enterprise market, it only occupies 1% in the hard disc market.

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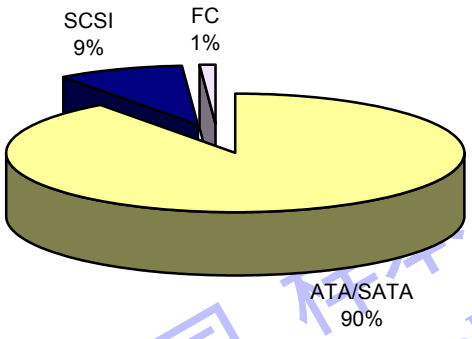
2002 Global hard disc sales quantity percentage (by hard disc interface)



Source: Dataquest, Hard Disk Drive Market, March 2002

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A comparison of major hard disc interfaces

	IDE/ATA	SATA	SCSI	FC
Introduction period	Middle of 1980	End of 2002	Beginning of 1980	End of 1980
Length of bus line	45cm	1M	Up to 12M	Up to 10KM
Single port transmission speed	133MB	150/300/600MB	80/160/320MB	200MB
Number of hard disc that can be connected to	2/channel	Point to point, expandable	15/channel	128/channel
Point to point connection	No	Yes	No	No
Setup and adjustment	Need	No need	Need	No need
Transmission method	Parallel	Serial	Parallel	Serial
Price	Lowest	low	medium	high
Application market	desktop PC	desktop PC/server/Disk Array	server/Disk Array	server/Disk Array
Application of storage architecture	DAS, NAS	DAS, NAS, SAN	DAS, NAS, SAN	SAN
The whole market share in 2002	90%		9%	1%

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Desktop market share	99.6%	0.4%	0%
Enterprise market share	10.3%	78.7%	11%

Source: Dataquest2003, summarized by PROMISE

Revolutionary new storage interface: Serial ATA

The spec of Serial ATA 1.0 is co-made in 2001 by APT, DELL, Intel, Seagate, Maxtor, etc. The initial main purpose of SATA is to replace ATA, relative to ATA, SATA has many revolutionary improvements:

- Finer cable to solve the space management issue within the computer frame.
- Faster and more effective serial transmission enables the transmission speed of 1.5Gb, 3Gps, 6Gps.
- Less pin count.
- More power-saving
- More direct connection, no M/S setting is necessary.
- Support hot-swap

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These milestone improvements have made SATA a even friendly product than SCSI and FC, to storage system itself, the superiority in price/performance ratio has mande SATA the optimum replacement for SCSI or FC. In the past, ATA hard disc is inferior to SCSI in both speed or stability, plus the limitation in cable length, it is thus not widely used in the enterprise storage environment, however, the new generation SATA interface seems to re-write the hard disc history. SATA Workgroup has made a seven year plan for SATA spec in one time, this includes the main specs of SATA first generation (1.5Gb), second generation (3.0Gb) and third generation (6.0Gb), even the related storage in NAS is planned, SATA is never inferior to SCSI in terms of its superior transmission speed and more advanced functions. Most importantly, it inherits the low price superiority of ATA, it is believed to gradually penetrates into the SCSI's application in enterprise storage market. The reasons are as in the followings:

- ATA hard disc has become more stable and mature in technology.
- Price superiority, with price of 2 to 3 times lower than SCSI.
- Breakthrough design in spec and function.
- Optimum price/performance ratio

Spec comparison between Serial ATA and traditional Parallel ATA

Spec comparison	Parallel ATA (parallel)	Serial ATA (serial)
Software compatibility	-	Compatible to Parallel ATA software
Price	-	Similar to parallel ATA (but higher in price in the first step)

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Support outer equipment	No	Under preparation
Support ATAPI	Yes	Yes (schedule is slower)
Support PIO and DMA mode	Yes	Yes
Support CRC	Data CRC check only	CRC check for Command & Data
Support hot-Swap **Transmission rate**	No 133MB/s	Yes 150MB/s (first generation)
Cable connector	40-pin	7-pin
Power supply connector	Traditional 4-pin power supply connector	Smaller (but both will be provided in the first step)
Connector size	Large (6 x 0.9cm)	Small (1.7x0.5cm)
Cable length	45cm	1m
Effective signal number	29-pin	4-pin
Signal voltage	3v, 5v tolerance (single end)	0.25v +/- 0.25v (differential)
Power saving	-	More power-saving on the signal transmission and more power supply management modes are provided.
First party DMA	No	Yes

3.1.3 RAID HBA, Host-Based Adapter

RAID technology is the core of storage device, its main role is to act as a bridge between hard disc (data storage media) and the system host, its function is to manage all the storage space within the hard disc, to manage the execution of reading and writing, the optimum allocation of data, the enhancement of data I/O performance, and the most importantly, protect all the data within the hard disc and provide a backup mechanism of online backup so that a mission of non-stop operation can be achieved.

RAID HBA is an adapter controller inserted on the mother board, usually, there are many interface ports (2 ports~12 ports) on the HBA to connect several hard discs, it can be connected directly and internally to hard disc (mainly based on ATA, Serial ATA or SCSI) or connected externally to outer equipments (it is normally based on SCSI interface, but some suppliers plan to turn Serial ATA into externally connected interface).

RAID HBA is usually used in large host or high level server in the past, and all are SCSI interface, high cost is a natural thing. However, since PROMISE Technology Inc. introduced RAID into the IDE/ATA market in 1997, RAID has become widely accepted in the medium and small sized enterprise server environment and PC system. As compared to traditional SCSI RAID, Serial ATA/ATA along with its cost superiority (about 1/2 to 1/3 of SCSI RAID), is seen as one with future high growth in the industry. Current RAID HBA can be divided into different interfaces such as: SCSI, ATA, Serial ATA, FC.

PROMISE Technology Inc. is the leading supplier in ATA RAID HBA and Adaptec is

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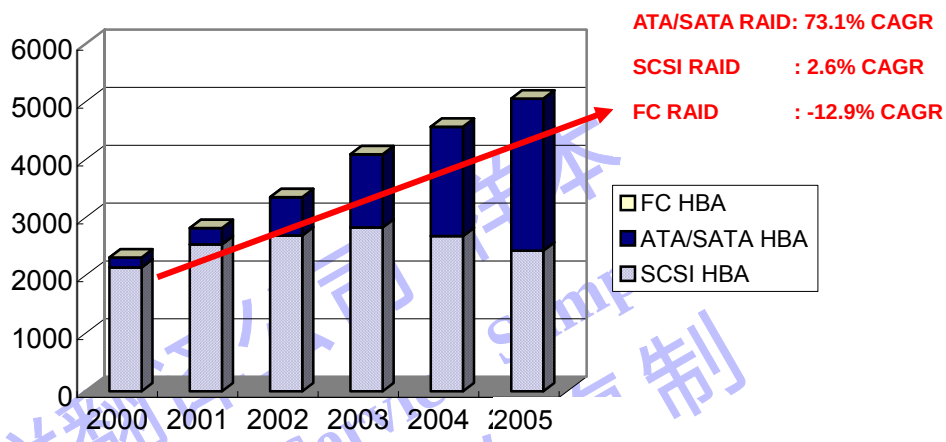
instead the leading supplier in SCSI RAID HBA.

Global RAID HBA global sales (by hard disc interface) 2000-2005

Unit: thousands sets



Source: Dataquest, Host-Bus RAID Controller Worldwide Market Share, December, 2002

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3.1.4 RAID controller

As compared to host RAID HBA, RAID controller usually exists in a storage system which is excluded from the server, it can be connected externally and serially to 15 sets of device based on SCSI interface; normally, SCSI hard disc is adopted as the hard disc within storage system, however, due to cost consideration, there is a trend that many storage systems gradually adopt ATA or Serial ATA hard disc.

RAID controller connects at one end to internal hard disc for communication and array management and at another end to external server host for good data I/O performance, therefore, the following characteristics are important, such as its compatibility to operation system on the host end, Failover redundant capability, its support to all kinds of backup components (for example, backup power supply, backup electric fan, backup hard disc), etc.; therefore, RAID controller is more complicated in design than other PC products, besides, user friendly nature of design in the array management software is very important too.

Types and application of RAID controller

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Storage architecture	Host interface	Types of RAID disk array card/controller	Application trend	Target (current)
DAS (built in RAID)	PCI	PCI to ATA/SATA	good	Desktop PC
		PCI to SCSI	low	For medium and small sized enterprise
DAS (externally connected to RAID)	SCSI	SCSI to ATA/SATA	high	
		SCSI to SCSI	low	For medium sized enterprise
FAS (SAN)	FC	FC to ATA/SATA	best	For medium and large sized enterprise
		FC to SCSI	medium	For large sized enterprise
		FC to FC	good	For large sized enterprise
	IP (Ethernet)	iSCSI to ATA/SATA	best	For medium and small sized enterprise
		iSCSI to SCSI	medium	For medium sized enterprise
FAS (NAS)	IP (Ethernet)	IP to ATA	best	For medium and small sized enterprise

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3.2 Storage System/Subsystem

The storage environment in the past is simple, for the management convenience purpose, general server will include storage function (host system integrates disk array device); however, the expansion in digital data in recent years is too rapid, and under the trend that the backup management function needed in the storage becomes more and more complicated and hard disc capacity becomes larger and larger, storage device is thus gradually separated from the host system to form an independent device. Therefore, the targets currently under discussion domestically are mostly storage subsystem, however, most giant players in this market on this definition indeed does not reach a consensus, they are thus normally called storage system.

Global RAID-Based storage systems are currently almost US-based PC/server companies, it is a market occupied only few players and of high entrance barrier, the top three players HP/Compaq, EMC, IBM occupy a market share of nearly 50%, the top 10 players in this storage market are: DELL, EMC, Fujitsu, HDS, HP/Compaq, IBM, NEC, Network Appliance, SUN.

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What is "storage system"

According to a definition from IDC, a disk storage system equipment should include several key components, these include RAID controller, cable for data transmission, host adapter, at least three hard discs, and storage management application software. Storage system can be installed inside the server, or can be connected externally to the server. Generally, the target market of storage system follows the server market of the enterprise, it can be briefly divided into work station/ small sized enterprise, medium sized enterprise, large sized enterprise , etc.

3.2.1 Market segment and definition (1): target market

Storage systems are mostly connected or used in the server environment, based on the deployment environment, storage market can be divided into small sized enterprise (Entry-Level)→ medium sized enterprise (Mid-range level)→Large enterprise (High level Enterprise), among them, the medium and small sized enterprise has the highest growth potential (as shown in the figure), however, the growth in higher level or large host is going to stay stagnant. The classification on storage system form IDC based on the price (from hundreds of thousands to tens of millions) are roughly nine grades (Brand 1~9), Dataquest further divide it into 6 grades based the number of hard disc used (Class 1-6,hard disc ranging from 1~129 sets), we can thus see that most storage systems are still used in the enterprise environment, and the host is mainly based on high speed storage interface (such as SCSI or FC optical fiber); for the hard disc interface used for storage, due to the continuous enhancement in stability and speed of SATA hard disc as well as the concern for the reduction of IT total cost of ownership

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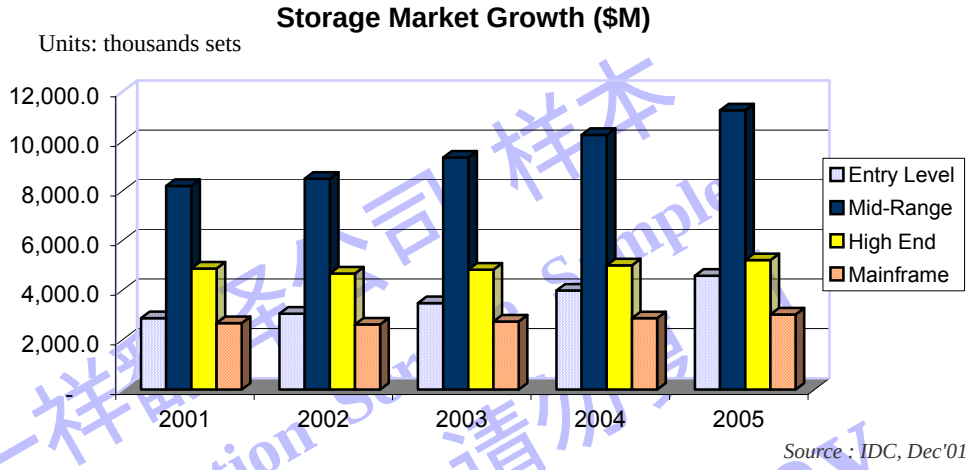
(TCO), etc., it is no longer limited to the more expensive SCSI or FC optical fiber hard disc; for example, CLARiiON of EMC is an optical fiber storage system where FC has been converted to ATA hard disc, this proves that stable and low cost ATA, SATA hard disc has been gradually applied to higher level FC storage system.



Source : IDC, Dec'01

3.2.2 Market segment and definition (2): storage architecture

According to the newest Dataquest report, August 2002, it divides Disk Storage market into two main structures:

3.2.2.1 Network storage system (FAS: Fabric-Attached Storage)

It commonly means storage system that can be connected to network environment which possesses the industry standard, that is, the currently widely used TCP/IP or optical fiber technology. No matter it's the widely familiar NAS (Network-Attached Storage) or SAN(Storage Area Network), since they possess both network connecting function and become a merging version in application, they are no longer simply independent architecture, therefore, Dataquest calls the integration system of NAS and SAN as FAS. In the future, when internet and SAN standards from different suppliers gets more integrated or when the product gets more stable, we believe that FAS market will become more mature.

3.2.2.2 Direct-Attached storage system(DAS: Direct-Attached Storage)

DAS mainly means those storage systems without network connecting functions, these include a host built in with RAID HBA card, or a storage device (with built in RAID controller) which is independent from the server, they can be further divided into three major types (please refer to chapter 3 for more details).

Take a glimpse at the current market, DAS is the most frequently adopted storage solution currently, it occupies a market share of 63% of the overall storage market, among them, SCSI RAID has a share of about 60%; however, since the new generation Serial ATA has broken the limitations such as functions and transmission methods inherent in traditional ATA, Serial ATA RAID is expected to rapidly replace ATA RAID market and erode the market occupied by SCSI RAID. ATA RAID leading supplier

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PROMISE Technology Inc. and Dataquest forecast that in between 2001 to 2005, Serial ATA RAID is going to have a compound annual growth rate of about 56%.

3.2.3 Market segment and definition (3): Storage file transfer protocol

3.2.3.1 File-Based transfer storage system

File transfer protocol uses file as an unit, NAS connected within TCP/IP architecture is such an example. Since file layer protocol controls file down to its name and attribute, therefore, its technical level is higher than Block layer; the major benefit of using file as transmission unit is that it is more convenient to the user, however, its disadvantage is that it could easily cause traffic jam due to shortage in network bandwidth.

- Network-attached storage system NAS
- Switched NAS

3.2.3.2 Block-Based transmission storage system

File transfer protocol is based on Block as unit, the protocols which control IDE, SCSI and FC are such examples; the general DAS, SAN all belong to this type of Block-Based storage system.

- Scalable Storage Subsystems
- Non-Scalable Storage Subsystem (Disk and magnetic tape)
- Network related device or accessory (Appliance, router, Hub/Switch/Director)

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3.2.4 Main functions of storage system

- **Scalability:**

As internet data grows several times each year by following “Moore’s law”, storage architecture changes its face too from “Server-Centric” to “Storage-Centric”. Therefore, facing the trend of several times increase in the amount of future data, the scalability of a storage system should be seen as a first priority; that is to say, how to let the storage system in a company to own the maximum flexibility and scalability yet under the minimum budget; and how to take care of also its compatibility to other system or platform so that IT personnel can easily set up and manage the system without new expense on the new installation.

- **Stability/Reliability:**

It is a system that possesses Back-up capability and 100% Fault-Tolerant mechanism so that it will not cause malfunctioned or damaged storage system due to the accident caused by any component. Currently, the online hardware backup method is commonly used to share the possible risk of malfunctioned machine, these include RAID storage

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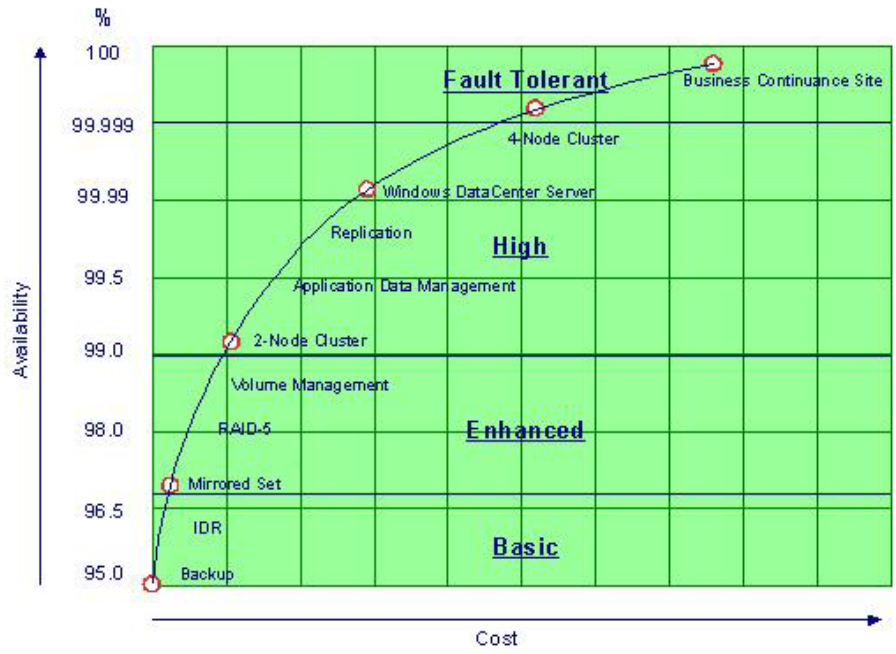
system, clustering system, backup power supply, backup electric fan, etc..

- **Availability:**

It mainly the back-to-online and system operation recovery capability when system is down, this is to prevent failure and to shorten the recovery time. For example, high availability means the operation rate of the system is increased to 99.999%, this is equivalent to only about 5 minutes of machine down time in each year.

Availability can be divided into different levels:

1. Basic availability (95% uptime): Good backup and recovery.
2. Reinforced availability (99% uptime): This includes basic availability component, advanced backup/recovery, basic disk management, and RAID 0/1/5 and hardware backup.
3. High availability (99.999% uptime): These include availability component, advanced disk management, copying, clustering and third-mirror break-off.
4. Fault-tolerant (100% uptime): These include availability component, 4-node clustering and further hardware backup.



Source: taiwan.cnet.com

- **I/O Performance:**

Storage system has to face massive digital data transmission and multiple persons on-line data Read/Write in the same time, it can effectively enhance access speed; besides, how to maximize transmission performance under limited bandwidth is also a consideration in selecting storage system. 以FC來說，可提供每秒2Gbps之傳輸效能.

- **TCO (Total Cost of Ownership):**

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In evaluating the cost, in addition to the hardware cost during the purchasing such as: server, storage device, hard disc, etc., it also includes operation system cost, installation man power and time cost and the future maintenance cost and expansion cost.

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3.2.5 Trend analysis of storage system

3.2.5.1 Storage system goes toward software value-added design

As hardware market becomes more and more mature, the integration of software is an inevitable trend.

Hardware giants such as: HP, IBM, EMC, HDS, etc., have moved their focuses in recent years to the software development, they invest more and more on the high profit software development one after another in order to increase market share and vertically integrate product line. For example, EMC merged Astrum and Legato in this year, HPQ and IBM announced Storage management software respectively, SUN and Veritus cooperates in marketing efforts, etc., we can find a trend that storage system hardware giants gradually turn their focuses to value-added system.

The main reasons are as in the followings:

1. As storage system hardware technology is mature enough, the market demand is well satisfied.
2. IT budget reduction has lead to stringent competition in hardware price.
3. Due to total cost of ownership (TCO) consideration, software automation can gradually replace partial manual management.
4. As Bluefin software management is promoted, the software integration and uniform interface as well as wider application are speeded up.

3.2.5.2 The emergence of network storage system NAS and SAN

There are two major interfaces storage system applied in the networking area: One is FC, another is TCP/IP.

Although NAS uses network TCP/IP for data transmission, the File-based transmission as well as Block-based transmission used for database data transmission obviously face bottleneck. Due to its high total cost of ownership, FC can not be widely used in the Fabric-Attached Storage market, some forecast that in the next few years, FC will drop itself gradually from the mainstream market, it will be left limited to SAN environment of large sized enterprise. For medium and small sized enterprises which rely so much on standard Ethernet and internet protocol（IP）, the more economical IP Storage will be a best choice; the current iSCSI interface which is based on IP technology has followed the existed Ethernet architecture and cheap trend and will become the main storage system in low level SAN environment.

The major reasons are as in the followings:

1. Ethernet is still the mainstream internet protocol currently used in the enterprises.
2. Ethernet installation is simpler than FC .
3. Ethernet environment is mature, storage system can be plugged and played, there is no additional re-learning cost.
4. Ethernet related component is cheaper (Switch, Router, etc.)

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3.2.5.3 High level array system has entered its mature period, it has to face low price competition pressure

Analysts forecast that the enterprise data grows at an annual rate of 80%, however, the budget is not increased. This means hard disc gets larger in its capacity but the price gets cheaper; as the technology and function of array system get more mature, it can handle the need from large sized enterprise. This kind of trend will have three results for the array system:

1. High level storage system becomes smaller and price competition becomes inevitable.
2. Storage system will have relatively larger growth space in medium and low level market.
3. Storage system in medium and low level market will catch some high level functions but provide a solution of low price and complete function.

3.2.5.4 Virtualization, automatic management

RAID is itself a product of virtualization management concept. As hard disc capacity gets larger and larger, smarter CIO values more on the so-called ROI of storage capacity, that is, the utilization rate and efficiency of real data in storage system and the economic performance cost of each storage unit an man power management cost. Such market need on the “performance management” topic for related data will force storage system to head toward a virtual management design with multiple elements.

3.2.5.5 Partial integration between NAS and SAN storage system

This part will be investigated in more details in the coming chapters.

3.2.6 The role of PROMISE Technology Inc. in the storage system market

PROMISE Technology Inc. integrates its professional technology for more than a decade in ATA/SATA field and its strong global marketing capability, it positions itself as a provider in the total ”ATA/SATA RAID-based” storage system product and key components, it provides personal customer or medium and small sized enterprise with complete storage solution in AS, NAS and SAN along with its product strategy of “low price but high standard”.

PROMISE Technology Inc. provide complete RAID solution for storage system:

1. Core disk array engine

PROMISE Technology Inc.has most of the RAID core technologies for storage system, from key component hardware such as: RAID Firmware, disk array management software, RAID ASIC engine, to RAID controller, etc. In storage system, RAID controller plays a most important role, it provides capacity and virtual data

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management for a complete storage system.

2. Core disk array management software

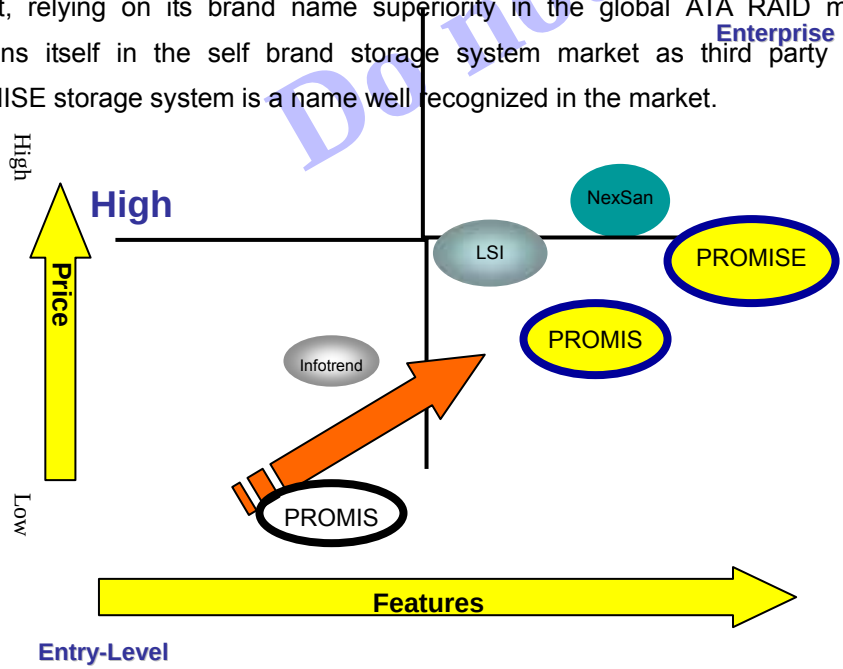
In order to add more values to the data management function by storage system, and in addition to RAID controller, PROMISE Technology Inc. also develops itself design array management software, for example, WebPAM (PROMISE Array Management) which lets MIS can easily monitor and manage the configuration and array environments such as: hard disc, temperature, cooling fan, etc. through web-based method.

3. Storage system integration design

Being different from other RAID controller ODM/OEM designer or system integrator, PROMISE Technology Inc. independently develops designs and integrates all the component designs of a storage system, it has its own integration capability on storage system and is only few of the RAID system suppliers which have vertical integration and R&D capability.

4. Self brand storage system designer and supplier

According to Dataquest, HPQ, EMC, IBM., etc., the top ten storage system suppliers occupy about 85% of the global RAID-Based storage system market, it is a Captive market. PROMISE Technology Inc. has a global market share of 87% in ATA RAID HBA market, relying on its brand name superiority in the global ATA RAID market, it positions itself in the self brand storage system market as third party supplier, PROMISE storage system is a name well recognized in the market.



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3.3 Storage management

“Integration” and “automation” is the future storage management trend

Storage means the movement, placement and acquisition on data based on Physical, Logical or Virtualization concept; no matter which storage body the data is placed, it still keeps its availability. In the meantime, it plays a role as the working bridge between storage system and application software, it also provides an integrated and automatic storage management solution; meanwhile, it is a smart mechanism which automatically monitors, reports, integrates, manages and recovers data so that IT personnel can easily installs, maintains and manages it in the least man power and in shortest time. Therefore, under the heterogeneous environment system, storage, network and diversified storage architectures, how to effectively integrate and provide automatic management functions has become the key design topic of the current storage software giants.

Traditional management software is included in operation system, however, as the storage environment becomes more and more complicated in recent years and storage system functions get stronger, the enterprise storage solution has deviated the master/slave structure of traditional server, the role plays by storage management in the whole storage solution has thus become an industry with total sales up to 10 billions US dollars; IDC forecasts that the storage software in between 2001~2005 will have a compound growth rate of 26.1%, storage management market will have the highest growth rate in all storage sub-systems.

Storage management can be divided into four main functions and types:

1. **Data backup and protection**

80% of the storage management software provides such functions.

- Hierarchy Storage Management (HSM)/ Archive
- Backup/Restore

2. **High availability**

When scheduled or non-scheduled system down has occurred, data hook-up and recovery capability is guaranteed.

- Backup at different place/failure takeover
- Clustering management

3. **System and organization management**

Integrated use and allocation management are performed on storage capacity, storage subsystem, related storage management services, etc. through the use of logic or virtual method.

- Storage virtualization
- Resource Management

4. **Internet-oriented management**

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This means that effective integrated management can be performed on “heterogeneous” network storage environment such as: multiple vendors, multiple internet communication protocols, etc.; meanwhile, automatic recognition and monitoring of each storage hardware and software device and equipment, such as: Topology or Switch, etc., can be achieved. Currently, it is mostly used in the SAN storage architecture and environment in large enterprise.

- Storage system /component management
- Network equipment management

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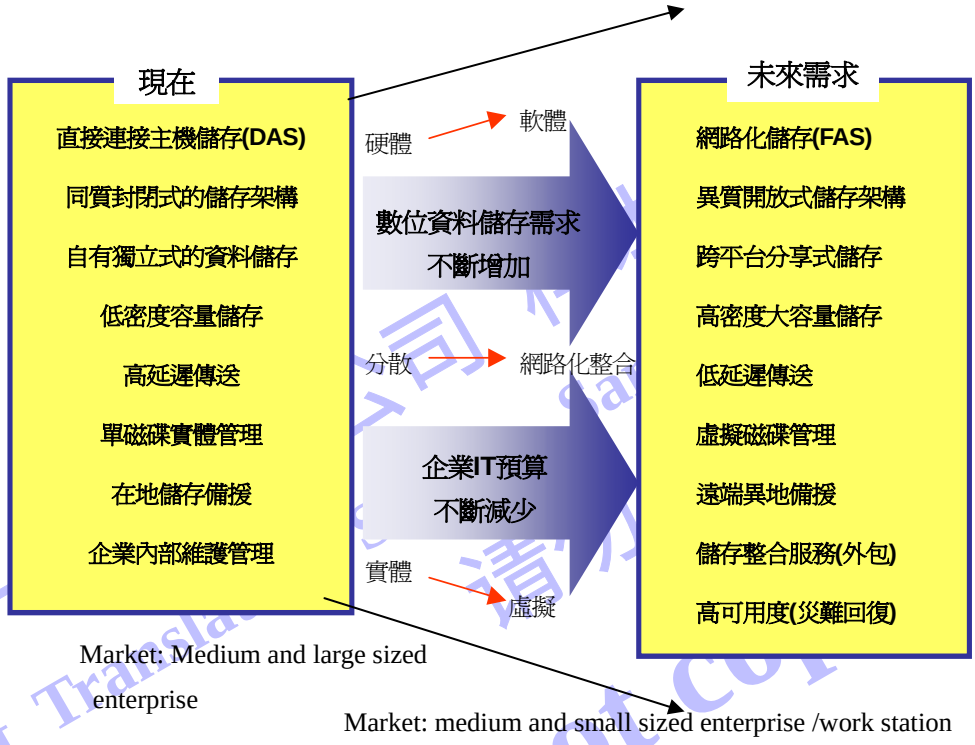
3.4 Chang and trend in storage industry



Major technological revolutions

Before understanding storage industry trend, we should understand first what major technologies and their indexing meanings to the later storage industry trend.

Announcement	Technology revolution	Effect
2000	iSCSI protocol technology	It is the major catalyst which speed up the application of SAN in medium and small sized enterprise.
2001	Serial ATA protocol technology	Solve the ATA hard disc transmission bottleneck and step into Gb high transmission hard disc I/O protocol and enterprise user storage market
2002	Bluefin technology	Uniform storage software standard
2003	PCI Express technology	Solve the current PCI bottleneck and step into Gb high transmission bus I/O protocol

The impact brought about by SATA and iSCSI: Low price trend of Fabric-Attached Storage

In 2000, the new transmission protocol —SATA and iSCSI has changed the trend in storage industry, there are three major effects, the first is the combination of network and storage technology, the two major technology combinations in iSCSI has made medium and small sized enterprise be able to use Fabric-Attached Storage product of SAN with low cost. The second one is that SATA becomes a hard disc storage

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interface which realizes low cost and NAS performance. The third one is that as desktop PC is going to step into Gigabit high transmission era, the high transmission environment is going to enhance the application of low level storage (Wintel) in the value-added PC users.

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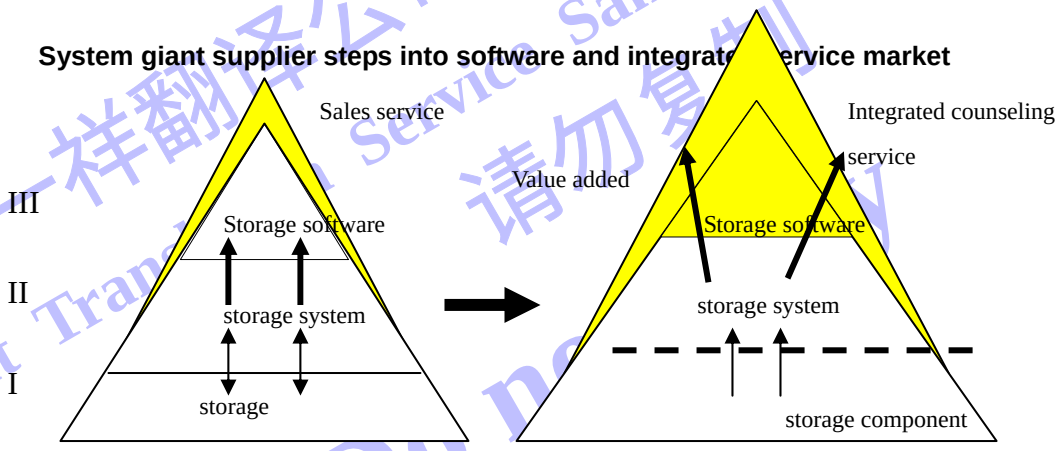
The attributes of storage industry:

1. It is US based market monopolized by few players with high market entrance barrier.
2. It is in technology innovation period with high technology entrance barrier.
3. Long product life cycle with loyal customer.
4. An industry with technology-oriented and brand name service-oriented nature.
5. An industry with focused strategic alliances.

Industry trend:

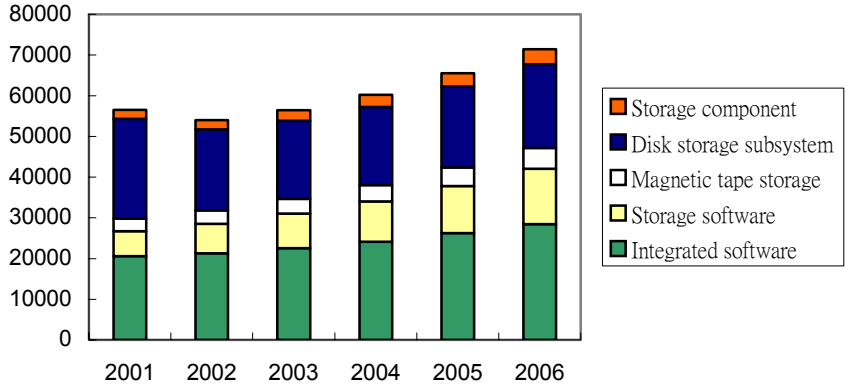
1. Storage system/software steps into vertical integration market

System giant supplier steps into software and integrate[d] service market



In the pyramid industry, system giants gradually move from the second layer to the third layer sub-industries, they step into storage software management market which has higher profit. They try to create value through vertical integration and build up the entrance barrier higher; for long term speaking, storage system giants will head toward the service market of vertical integration such as: providing integrated and value-added product and service such as: server, storage system, software and hardware, network components.

Unit: mullion UD dollars **Global storage industry market (2001~2006)**



Source: IDC, Worldwide Disk Storage Systems Forecast and Analysis, 2002-2006.

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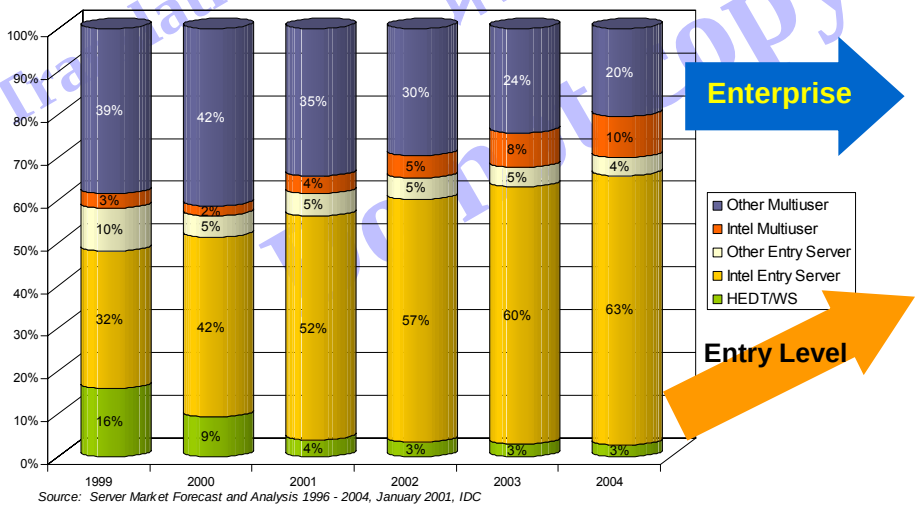
2. The coming of outsourcing ODM trend from the system giants

Storage giants will focus on high level and high value-added market block, however, to prevent the pressure of operation cost increase after vertical integration, the upstream key components such as some key hardware components: RAID HBA, Controller, etc. in the storage system should be outsourced to the ODM design company. The giant companies are going to find long term cooperation partners through strategic relationship so as to realize the interest of vertical integration.

3. Medium and small sized enterprise storage market has great potential to grow

RAID storage systems are mainly applied in the server environment of enterprise users. According to IDC, the servers sales in 2002~2004 had a compound annual growth rate of 11.37%, medium and small sized enterprise market share will rise from 57% in 2002 to 63% in 2004, it has the highest growth rate in all markets.



Source: Server Market Forecast and Analysis 1996 - 2004, January 2001, IDC

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4. Corporate storage architecture

Modes of storage system

The current modes used by normal enterprise in storage system can be divided into three main categories: Off-Line storage, Near-Line storage and On-Line storage.

- **Off-Line storage –** magnetic tape is the main type, these include D AT, DLT and LTO, etc., it is the traditional way enterprise used to backup super large data; however, since it is lack of mobility and efficiency, it is only used for simply backup or the third layer storage work of HSM (Hierarchical Storage Management).
- **Near-Line storage –** It usually stores data not needed immediately, it is a media with unit storage capacity not large yet convenient to access, for example, CD-ROM, CD-R, MO, DVD, etc. Due to its small unit volume and easy to access characteristics, it can be divided into market for personal PC storage or for long term storage, for example the CDR machine/cabinet in the database of a library or hospital.
- **On-Line storage –** From its name, we knows that data is stored in on-line way with the CPU, DAS (Direct-Attached Storage equipment), NAS (Network-Attached Storage equipment), SAN (Storage Area Network), etc. all use disk (so-called hard disc) to do On-Line storage. Unless scheduled or unscheduled machine turnoff, the guarantee of data for 7 days a week, 24 hours a day, and 365 days a year of access, or the so-called never-stop and on-line backup mechanism has become the top mission and goal of the storage system nowadays.

Storage linking structure —DAS and FAS (NAS, SAN)

Based on storage system equipment as the center, it is the connecting method among itself, the server (Host) and the network structure, it can be divided into three major storage environment applications such as: DAS (Direct-Attached Storage), NAS (Network-Attached Storage) and SAN (Storage Area Network). As “network-oriented storage” trend becomes clearer, Dataquest has included, in its newest report, NAS and SAN into FAS (Fabric-Attached Storage). Strictly speaking, SAN means a storage architecture concept, DAS and NAS are storage system devices, under the whole storage architecture environment, NAS can lie underneath SAN and be merged with SAN, they do not repel each other. In general larger enterprise, IT personnel will choose from these three storage methods for an integrated use according to different scale and need.

The earliest storage system lives inside a large host, it is an independent storage device, it is connected directly to the server host. Since it follows server host, it is thus named DAS (Direct-Attached Storage), it is the earliest On-Line storage system.

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However, as internet gets booming later on, the amount of data expands in several times, digital information content (multimedia, audio and video, animation, etc.) increases continuously, DAS storage can no longer handle the in-time expansion issue in network era. Therefore, NAS (Network-Attached Storage) is thus a storage product under network economy. However, there is still some limitations on NAS, for example, its File-Based transmission method turns the original jammed information highway in the internet worse; for continuous big file backup and simultaneous accesses by multiple persons, the limited 10/100Mbps transmission efficiency of IP is a big bottleneck, and the goal of concentrated management can not be reached. SAN (Storage Area Network) architecture was thus born in later 1990s, it mainly uses optical fiber channel for high speed (Gbps) data transmission, it can also be used for multiple persons to multiple persons communication, the whole storage resource can be effectively managed and integrated.

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4.1 DAS (Direct Attached Storage)

It is a storage system directly connected to the server (based mainly on SCSI protocol), called DAS. DAS currently is still the mainstream of storage system, it occupies about 60-70% of the whole storage system market. Since DAS is connected to server directly and mostly connected through mature SCSI technology, therefore, it is very easy to be installed and connected and easy to be understood; it is easily to be adopted when the enterprise is installing its storage architecture in the initial stage; general startup or small sized companies usually uses DAS storage system.

According to the definition by Dataquest, DAS can be divided into three smaller types:

Independent and externally connected storage system - External RAID Controller-Based Storage

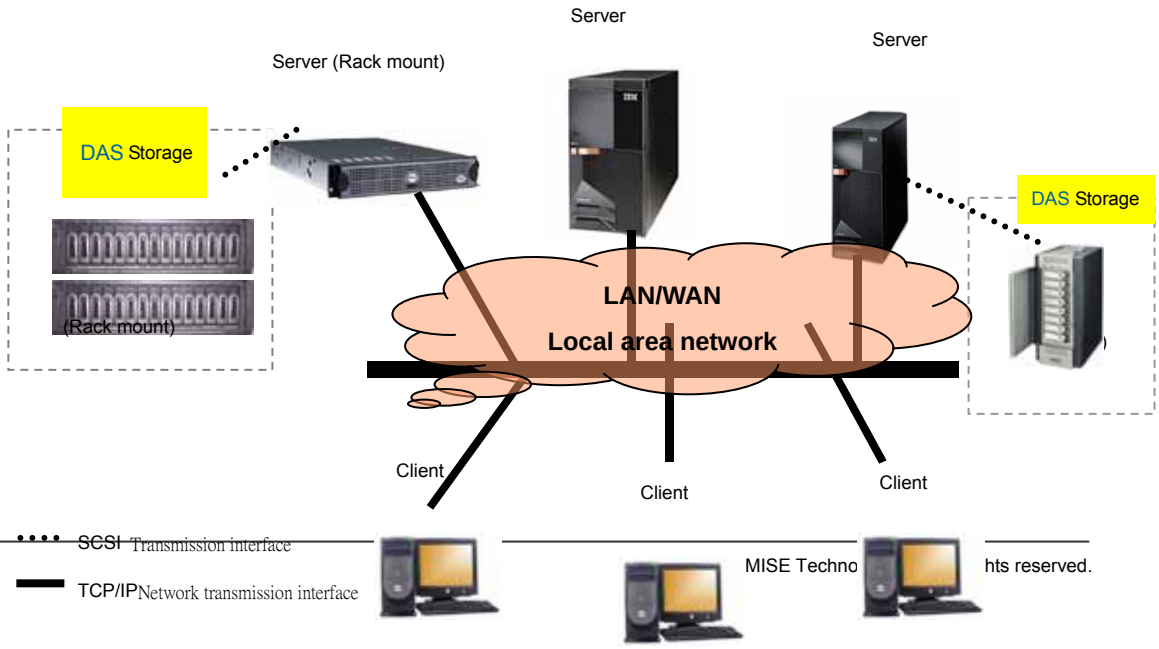
Storage device is separated from server, it includes disk array controller, multiple hard discs, it is an independent disk array storage system. The UltraTrak SX (vertical type)/RM (rack mount) disk array cabinet product series of PROMISE Technology, Inc all belong to this type.

Built-in externally connected storage system Host-Attached - External RAID Storage

Storage device is separated from server, but disk array controller is installed inside the server. Storage system is formed by many hard discs, it is used specifically for the execution big capacity backup job, it is thus also called JBOD (just a bunch of disks) and is rarely used in general enterprises.

Built-in storage system Host-Attached - Internal RAID Storage

The storage device is integrated inside the server, disk array controller and multiple hard discs are all built in directly inside the server. For example, FastTrak TX series (RAID 0,1,0+1 array card), FastTrak SX series (RAID 5 array card) and SuperSwap series (disk array hot-swap box) of PROMISE Technology Inc. all belong to applications in the built-in disk array storage system.



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4.2 FAS (Fabric-Attached Storage)

The integration trend f NAS and SAN= FAS

As mentioned before, Dataquest classifies NAS and SAN as inside FAS, this is a better definition method, it is generally called network storage system. The past Fabric-Attached Storage concept were all based on Server-Centric, however, when comes to NAS and SAN, they are changed to Storage-Centric. Simply speaking, NAS storage system is based on TCP/IP network transmission, it can be connected directly to the current Ethernet and is Plug & Play, therefore, it is cheaper; SAN network architecture goes through channel based on high speed optical fiber transmission, however, equipment such as network Switch needs to be added, the installation is difficult and price high. Currently, many industry observers say, the border line between NAS and SAN will become hazier and some of their characteristics will be integrated, NAS will become part of SAN, that is, a storage sub unit; SAN will have centralized management, low level NAS exists in distributed low capacity storage.

4.2.1 NAS (Network Attached Storage)

NAS is actually file share storage system in IP network. It has its own microprocessor, Micro-Kernel Operating System, file management system, network card and one set of built-in hard disc; what is special is that its operating system is burned into the firmware, file system is used to set up driver software for data access, the file standard is based on NFS of Unix server or CIFS protocol of Windows SMB. Since it is connected directly to IP local area network (LAN), not like DAS which is connected to server, therefore, it is like ”network neighbor” to the user, access to the data is very convenient. To MIS, the installation process and management are simple too, no high learning cost is necessary. Therefore, they are mainly used in environments such as: medium and small sized enterprise, departments with high need in file sharing, not too many servers, or heterogeneous platform, they can be expanded continuously.

The followings are advantages of NAS:

1. Since NAS is not connected to server, server’s performance is thus higher.
2. It uses current mainstream TCP/IP network for installation, no new storage architecture installation is needed, its complexity of introduction is much less than that of SAN.
3. It is compatible to heterogeneous platform and can be operated in different operating system.
4. Plug and Play, expandable, high flexibility.
5. It is frequently used in low data amount but many persons environment, or larger multimedia file which can not be transferred by Email, for example, Streaming, Video/Audio or CAD/CAM.
6. Low cost.

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The disadvantages of NAS:

Since NAS is connected to IP network and used in LAN, local area network, or WAN, wide area network; therefore, when there is a need on large data transfer, or file that operation is needed, the bottleneck of insufficient bandwidth is thus easily met, besides, the network resource will be occupied and network jam becomes inevitable. Furthermore, NAS can not perform concentrated management or higher level virtual resource management, it is kind of discrete single point storage.

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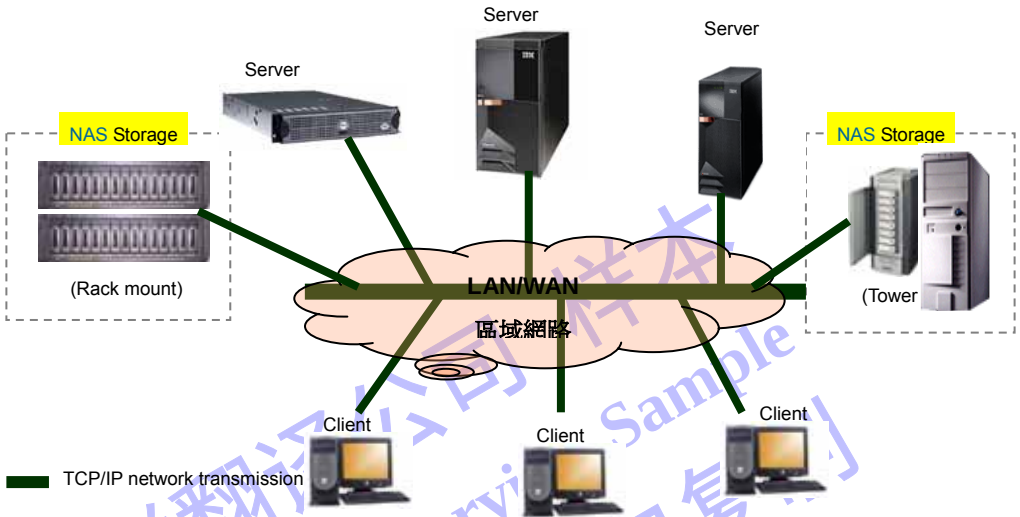
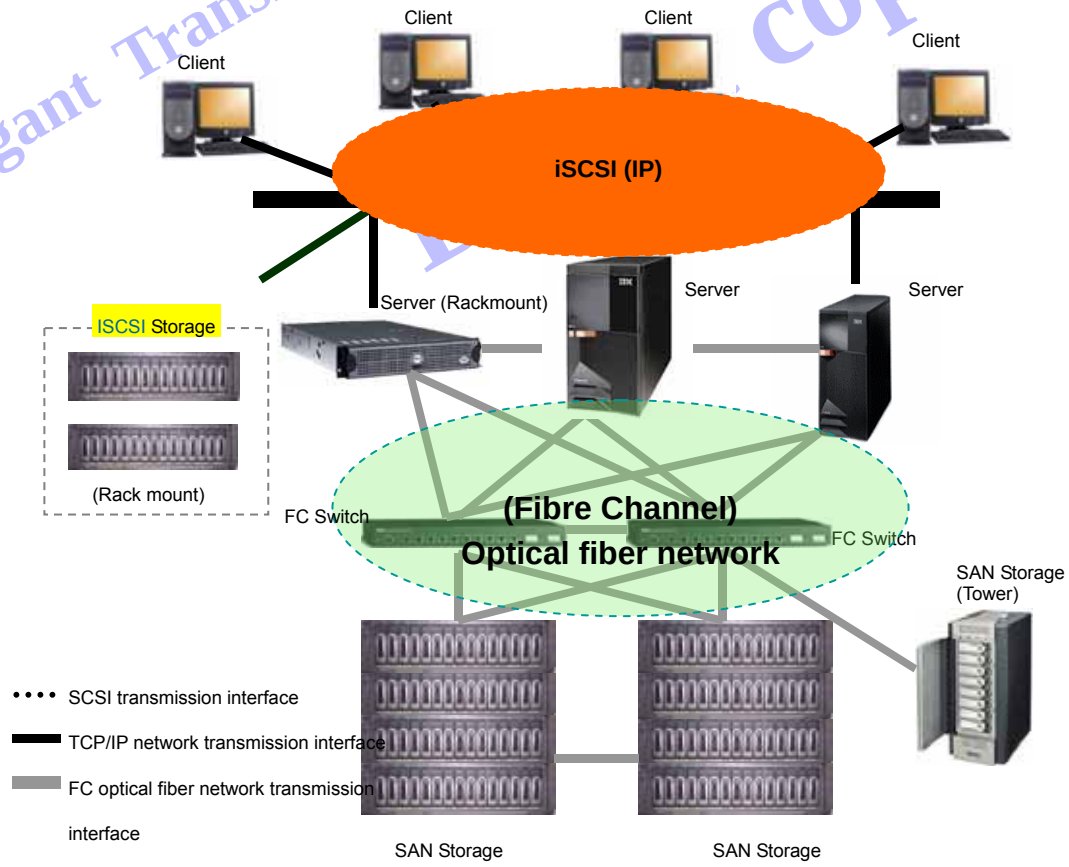
- **NAS storage environment architecture**



- **SAN storage environment architecture**



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4.2.2 SAN (Storage Area Network)

SAN is to build a high speed network storage architecture dedicated for data transfer. It isolates each storage system which was originally separated to each server as a Storage Pool, it can be connected to the server host through Switch or Flow Controller in Fiber Channel, or connected to existed Ethernet through iSCSI (Internet Protocol over SCSI) technology. The current market mainstream is Fiber Channel transmission technology, its largest spec advantages are a transmission speed as high as 2Gbps, clustering backup of multiple paths and distance layout above 10 kms; in management aspect, due to the concentrated share of storage resource, no bandwidth between LAN and server will be consumed; accompanied with management software, the storage space can be more effectively allocated, and the mutual operation between heterogeneous platform server and storage system is possible. However, the later emerging iSCSI has its superiority too, Microsoft announces recently that Windows operating system will be added with iSCSI storage standard, and iSCSI certification is launched too. The soc-called iSCSI is to build SAN network through IP transmission by using existed Ethernet, in other words, enterprise can use Ethernet to build low cost SAN.

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Components of SAN

An infrastructure is needed to build SAN, these include network equipment and device and storage system such as: fiber interface card is needed in the server host, fiber cable, Fiber Hub, Switch, Router, etc.; the basic cost will be more than one million NT dollars, and the installation is complicated too, therefore, very few enterprises use SAN, medium and small sized enterprise are even difficult to afford. SAN solution is proposed by Fabric-Attached Storage company such as EMC in later 1990s, it's not long since its first use in the enterprise storage environment, therefore, there is no uniform spec, protocol, standard or operation platform to be followed by enterprise; therefore, the "compatibility" issue among devices and storage system need to be considered during the purchase, however, the suppliers seem to notice this issue, they gradually provide high integration storage solution which can be operated across heterogeneous platforms.

The optimum SAN solution for medium and small sized enterprise: iSCSI

Since SAN is still immature in both technology and market, it is still in its infant stage, each supplier has its standard and finds aggressively the support from other related manufacturers so that it can lead the development of SAN. In order to prevent the compatibility issue among different devices, IT personnel might have to purchase a total solution instead of purchasing flexibly a single product. iSCSI emerges to solve the above problem, it provides a cheaper SAN environment which does not goes through fiber channel for medium and small sized enterprise.

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iSCSI will be an important technology to bring up SAN application

iSCSI represents a standard communication protocol, it packs SCSI command into TCP/IP packet, SCSI command is transferred through Block method in different IP networks, therefore, it can speed up the data transfer in intranet, besides, the storage can be managed remotely. It is generally known that iSCSI protocol will be the key technology that will bring the rapid growth in local area network SAN, it is believed to enhance the transfer function and efficiency of stored data. Due to the popularity of IP network, iSCSI can transfer data through LAN, WAN or internet. The difference between SAN network and Network-Attached Storage gradually becomes hazy, the emergence of iSCSI is going to speed up this development further. iSCSI was proposed earliest by giant suppliers such as: Adaptec, Cisco, IBM, etc.; currently, it has solutions such as: HBA, chip, software or storage network card, etc.

Comparison between SAN and NAS

	SAN	NAS
Communication protocol	iSCSI FC Fiber channel	TCP/IP
Data transmission object	Block	File
Transmission efficiency	2.5Gbps~10Gbps	10/100 Mb, 1Gbps, 10Gbps
Cable transmission distance	Up to 10 Kms	-
Access speed	High access speed, this is because SAN is dedicated network environment.	Better than traditional storage system, but it consumes network bandwidth and is easy to be affected by network environment.
Storage resource allocation	Modularized storage and concentrated management	Distributed node storage, distributed management
Data share	Good	Normal
Installation flexibility	Normal	Good
Limitation by data type	No	Not suitable for data that needs large operation or massive data transfer

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Installation difficulty	More complicated in infrastructure and installation, IT personnel needs to be trained.	Plug and Play to LAN node
Target market	Online backup at different places for WAN and massive data, for example, database, ERP, OLTP backup, online trading, etc.	Figures in LAN, multimedia, file share of general document, etc.
Enterprise size	Large sized enterprise , data center	Medium and small sized enterprise , department data share
Capacity need	High	Medium
Cost	High initial cost of ownership	Low initial cost of ownership

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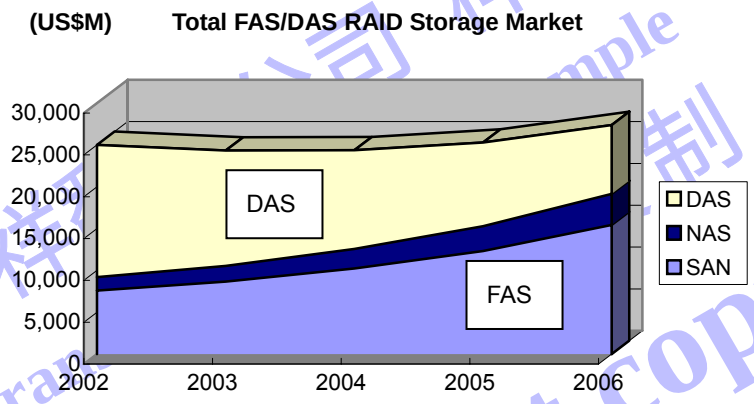
4.3 Trend analysis of storage architecture

1. FAS Fabric-Attached Storage mainstream trend---NAS+SAN

Since FAS has advantages such as: direct share over network, good expandability, longer transmission line, etc. over DAS; although DAS is still the current mainstream storage system (63%), FAS is going to be future storage system trend, Dataquest forecasts that total FAS will reach a market share of 60% in 2006.



Source: Dataquest, (August 2002)

Comparison among DAS, NAS, SAN

	DAS	NAS	SAN
Host connection interface	PCI, ATA/SATA, SCSI	TCP/IP	iSCSI IP FCIP, iFCP (fiber)
Network share	No	Yes (LAN)	Good (WAN)
Data transmission object	Block	File	Block
Cost	Low	Medium	High
Integration management efficiency	Low	Medium	High
Enterprise scale	Medium to large sized enterprise	medium and small sized enterprise	large sized enterprise , data center
Capacity	Low, medium, high	Low to Medium	High
Different place disaster recovery capability	Good	Bad	Good

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2. iSCSI will have high growth in low level SAN market

Currently, SAN uses FC as the major transmission interface, however, the market is concentrated on few large sized enterprises which can afford and have resource to maintain and repair; this is because the introduction of FC SAN needs to pay not only storage hardware such as: storage system, network Switch, Hub, etc., most importantly, it is very complicated in the initial construction, installation and setup, the internal human power education thus is very important. This why the introduction and popularity of SAN in medium and small sized enterprise is not as expected. Enterprise emphasize a lot on TCO efficiency, therefore, under limited IT budget, iSCSI is no doubt the only Low-cost SAN choice; we expect, iSCSI will initially have highest market penetration and highest growth in medium and low level SAN market, it will gradually eat away the current FC in SAN market. FC will eventually be positioned at high level SAN mainstream storage interface in order to be distinguished from medium and low level market.

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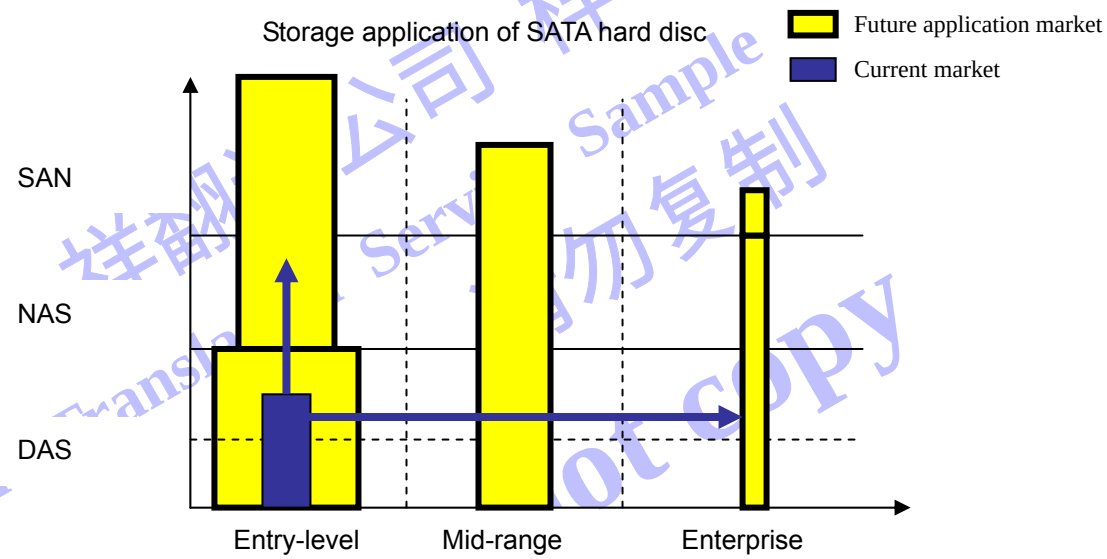
3. Storage interface trend----SATA RAID of unlimited potential: High market scalability

ATA hard disc has worse stability than SCSI in the past, plus bad expandability, it is thus used mainly in DAS storage environment.

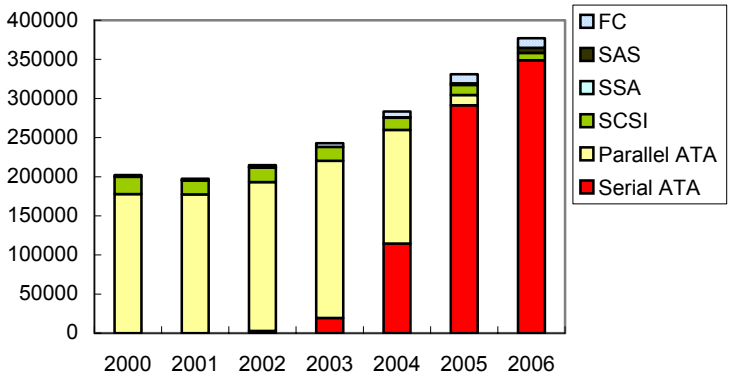
However, SATA not only inherits the low price superiority of ATA but also possesses excellent performance and revolutionary functional design, it thus gradually shifts from DAS application to a wider application market such as: NAS, SAN:



SATA RAID-based storage system will become the best choice for DAS, NAS, SAN low cost storage media, the applications of SATA hard disc not only include: Disk-Disk backup storage market, online backup storage, vertical application market, but also has the trend to replace traditional magnetic tape storage market (the application of SATA RAID will be published one by one in the future). From the following WWW hard disc sales quantity, SATA shows explosive growth in the future.

Unit: thousands sets

Future global hard disc sales forecast (by hard disc interface)



Source: Dataquest, Hard Disk Drive Market, March 2002

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4. ATA/SATA RAID is on flying—steps into medium level market

ATA hard disc is usually used in desktop PC in the past, as compared to SCSI and FC, the inherent spec limitation of ATA such as: stability, transmission distance, efficiency, no. of hard disc it can be connected to, etc., make it difficult to replace the need of SCSI and FC in the enterprise customer. However, the low cost advantage of ATA satisfies the low price market needs, the global ATA hard disc sales is about 90%, however, in the hard disc market used by enterprise, ATA hard disc only occupies a market share of 10%, SCSI hard disc is the current major storage media used by most enterprise customer. The market analysts think that SATA hard disc will replace old ATA market within 5 years and eat away SCSI's hard disc market in enterprise storage, after 2006, SATA is expected to exceed SCSI market. No only so, under the strong promotion from giant player such as Intel as well as the long term plan of three generations (1.5/ 3/ 6Gb), SATA is going to impact SCSI's role in the high level storage market in the future, the market expects that SATA in the short term will gradually replace the role played by SCSI in the medium level hard disc market, and starts to be used in some storage systems of medium sized enterprise, take a look for the long term, some large sized enterprises' storage systems will adopt low cost SATA hard discs as storage media to keep the lowest unit storage cost (the unit is each MB).

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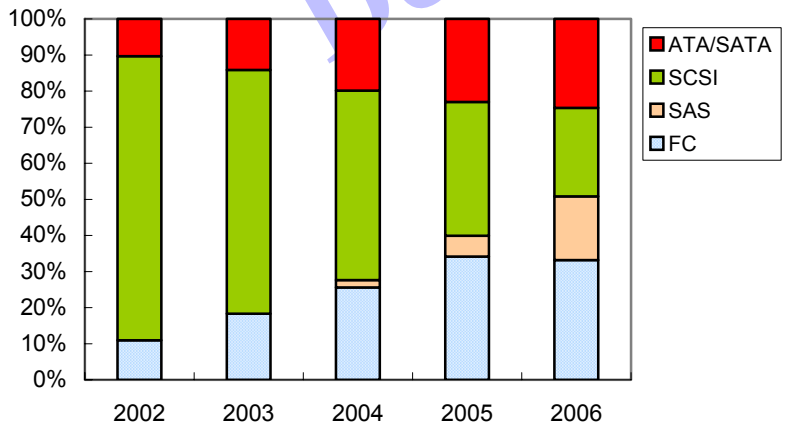
Market share forecast of global enterprise hard disc market (by interface)



Source: Dataquest, Hard Disk Drive Market, March 2002

5. FAS interface trend----the role and position of iSCSI and FC in SAN

The future market partition of FAS interface

	iSCSI (prototype IP)	FC (optical fiber over IP)
Target market	1. Medium and small sized enterprise 2. Departments in large sized enterprise	large sized enterprise

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Position	At the end of 2003, iSCSI will start to be used in medium and small sized enterprise market, the introduction of TOE technology will speed up market growth.	FC is still the current SAN market mainstream, if there are more value-added functions and software management, FC will still be the top choice for SAN.
Chance/threat	1. Low price advantage speeds up market cut-in and market share. 2. The maturity in 10GbE helps to replace FC.	1. Fabric-Attached Storage has become a trend, FC market is still prosperous. 2. It goes non-original IP architecture, therefore, it can not penetrate the existed Ethernet Fabric-Attached Storage market.

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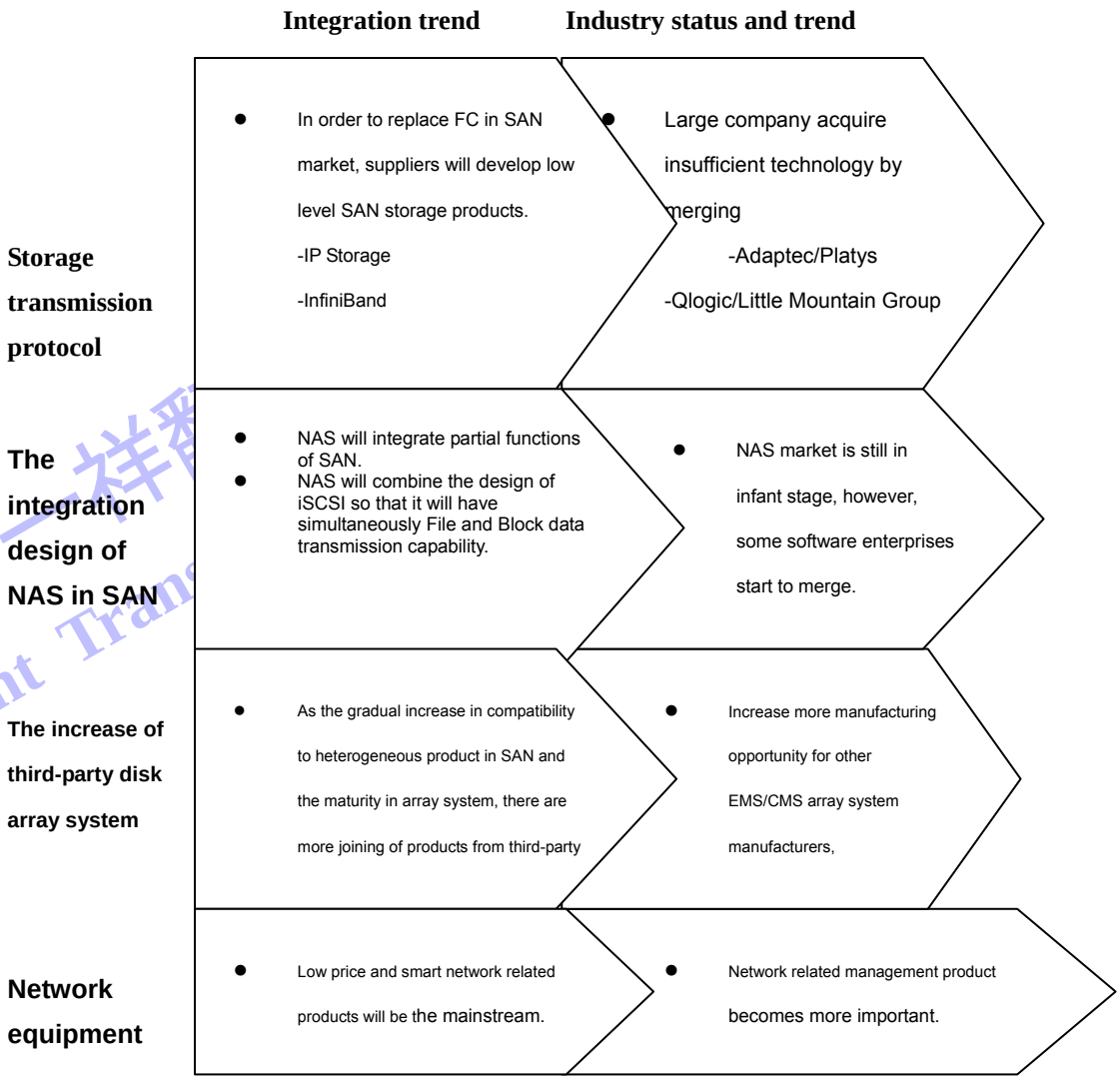
6. The integration trend of storage industry


Integration trend
Industry status and trend
Storage transmission protocol
In order to replace FC in SAN market, suppliers will develop low level SAN storage products.
-IP Storage
-InfiniBand
Large company acquire insufficient technology by merging
-Adaptec/Platys
-Qlogic/Little Mountain Group
The integration design of NAS in SAN
NAS will integrate partial functions of SAN.
NAS will combine the design of iSCSI so that it will have simultaneously File and Block data transmission capability.
NAS market is still in infant stage, however, some software enterprises start to merge.
The increase of third-party disk array system
As the gradual increase in compatibility to heterogeneous product in SAN and the maturity in array system, there are more joining of products from third-party
Increase more manufacturing opportunity for other EMS/CMS array system manufacturers,
Network equipment
Low price and smart network related products will be the mainstream.
Network related management product becomes more important.

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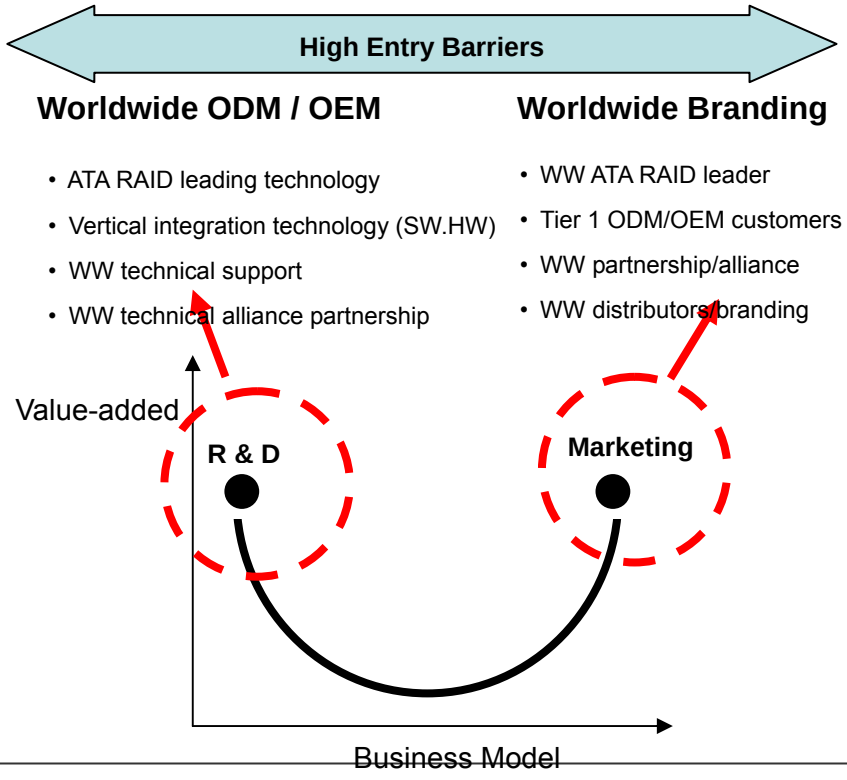
5 SATA/ATA RAID Storage Everywhere - PROMISE Technology Inc.

5.1 Technology, marketing, global deployment are enterprise's competitive advantages

PROMISE Technology Inc. aims at providing low price and high performance storage solution from its beginning, it positions itself as "ATA/SATA RAID-based Storage Total Solution Provider" and a complete storage architecture application solution in DAS, NAS, SAN. PROMISE Technology Inc. owns its own brand name known as "PROMISE", it's a locally and privately operated enterprise while deploys for the global sales channel, it is a global name enterprise in disk array. Since disk array is of higher technology as compared to other industries, there is no standard products and technological spec is lead by few international giant players; how to keep the cutting edge information and provide full technological supports as well as customer's recognition on our brand name are all the key successfully factors of PROMISE Technology Inc.

For more than a decade, the strong R&D capability of IDE/ATA, the superior quality and product's stability and compatibility have brought recognitions from international customers for PROMISE Technology Inc. no matter it is in ODM or self brand name market. The long term deployment in the global market and the good alliance relationship kept with international giant players has brought a strong position to PROMISE Technology Inc. in the disk array industry, it successfully owns the competitive advantage in the global market: these include the grasp of vertical integration technology, innovative and progressive R&D capability, high value-added product capability and global brand name sales channel.

In the mean time, built on high value business model of "smile curve", that is, technology and marketing superiorities, have made PROMISE Technology Inc. a strong position in the storage industry which is of high entrance barrier and difficulty of replacement.



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- **ATA/SATA RAID, the leader in global brand name with a market share of 86%**

PROMISE Technology Inc. is the only ATA RAID leading supplier from Taiwan well recognized in the global storage market with its own brand name. After it leads the world to promote ATA RAID HBA in 1996, it devotes itself in a strategy of providing Low cost/High performance RAID products, a complete storage solution as well as global but local marketing, this as made PROMISE a recognized name in the global market. PROMISE Technology Inc. has spent more than a decade in accumulating professional technology, product and marketing knowledge in ATA RAID product, the industry has a nature of high entrance barrier; along with the explosive growth of new generation of SATA, PROMISE Technology Inc. will no doubt be the direct beneficiary of SATA trend.

- **ATA/SATA RAID-Base, a total solution provider**

PROMISE Technology Inc., in the whole storage industry partitions, aims at providing ATA RAID solutions of storage component and storage system; starting from ASIC, RAID HBA to RAID Storage, it is a total storage solution of vertical integration. Face with future trend of low price/high performance in the storage market and the gradual increase in the storage demand of medium and small sized enterprise; SATA RAID, with its low cost, high performance and other breaking-through functions, as well as its SCSI-matched stability and expandability, it is no doubt going to replace SCSI RAID and expand upwards to the territory of medium level market.

- **A storage application solution provider for DAS, NAS, SAN**

ATA was positioned for low level market application in the past, However, as the technology gets mature, ATA will reach the stability of SCSI, but the price is only half of SCSI, it thus has drawn attention from NAS, SAN storage system suppliers and gradually stepped into medium and high level storage market application. PROMISE Technology Inc. grasps its superiority in existed ATA market, it continues to play its active role as SATA RAID-Based Storage total solution provider of DAS, NAS and SAN.

5.2 Technology trend

Complete “core” vertical integration technology to set up high entrance barrier

PROMISE Technology Inc. is the only global enterprise targeting at the R&D of ATA RAID related technology. PROMISE Technology Inc. develops related software and hardware such as: ASIC, BIOS, Driver, Firmware, RAID management software and

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System-Level, etc., it insists to grasp key technologies, its production line includes, RAID ASIC, RAID HBA to storage system and related software. In all the milestones of IDE/ATA related technologies, PROMISE is almost the nickname of world's number 1; no matter it is from hardware to software, or from ASIC to system, PROMISE Technology Inc. has its complete vertical integration technology capability in storage related key components.

storage system
- Multi-element storage system
- Storage equipment with superior price/performance ratio

Chip
- Assignned brand name by global PC/OEM palyers.
- The largest global supplier in ATA/SATA RAID product.

HBA interface card
- The only global supplier with the most complete ATA RAID product line
- Built in with global highest stability ATA RAID core chip.

Software design
- Owns mature and best stability driver program, BIOS
- User Friendly Graphics User Interface (GUI)

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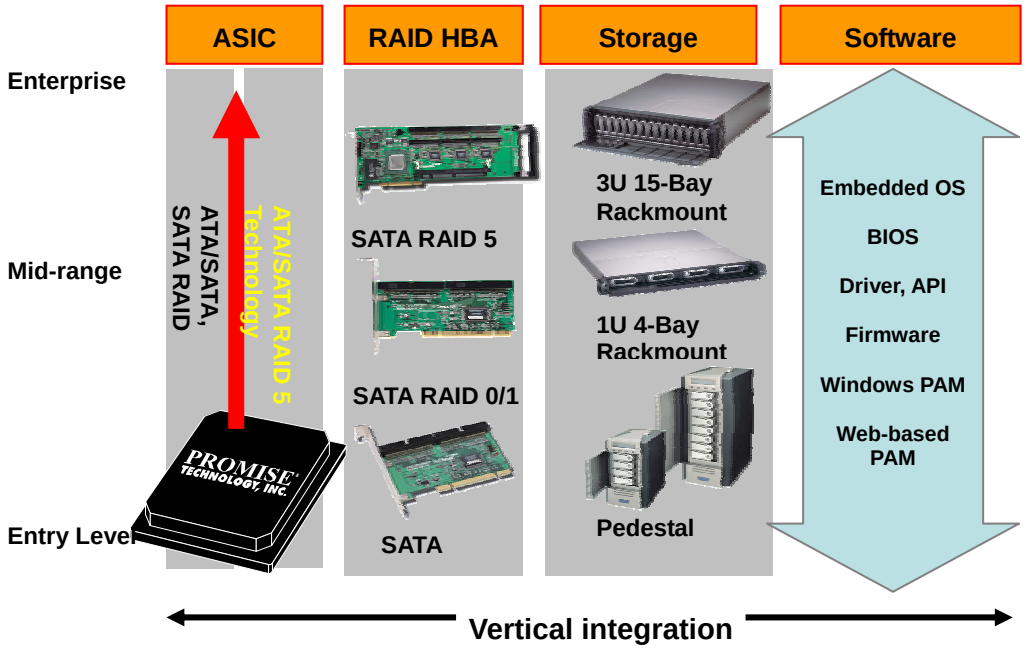
PROMISE Technology Inc. begins its business with the R&D of ASIC, since the role played by ASIC (the engine of RAID) in storage system is like the human heart, it is the most basic component of all storage system, PROMISE Technology Inc. uses ASIC as technology basis and origin, it goes downwards to extend its product value chain: RAID HBA, RAID system, it forms vertical integration technology with high entrance barrier. The RAID ASIC of PROMISE Technology Inc. occupies about 80% of the global ROMB market, and RAID HBA has a global market share of 86%, it is obvious that PROMISE Technology Inc. has its relative superiority in global technology.

Vertical integration technology and product of PROMISE Technology, Inc.



5.3 Participating the spec in international technology forum, acquiring technological making information ahead of our competiors

Since international large suppliers usually ally together and hold periodical technological or market forum in order to get leading position in the key storage technological specs. PROMISE Technology Inc. has a long history of close cooperation in technology or business with international large supplier, therefore, it has a lot of chances participating in international forums to grasp international technological information simultaneously and to acquire industry spec faster than its competitors; it also participates aggressively the spec and standard making in order to grasp the leading position in market. Face with the future trend of SATA, as a member in the international SATA industry association, PROMISE Technology Inc. has grasped the future impact and trend such as high speed transmission and low price that storage system has to face; it has also planned its new product for the exchange of new and old generation, it is well prepared.

Since it has grasped the industry trend in the medium and low end market in time, PROMISE Technology Inc. can thus make its own future product roadmap according to customer's need, it leads the market by half year to launch the product. Currently, due to its superior product quality and stability, Serial ATA RAID 5 HBA of PROMISE Technology Inc. has been adopted by NEC to be used in its server.

5.4 With its global brand name marketing superiority, high added value has been put to the product

PROMISE Technology Inc., as a total solution provider in ATA/SATA RAID, has become a leading global supplier in ATA/SATA RAID. PROMISE Technology Inc. is one of the very few Taiwan's enterprise that can stand at both ends of a "smile curve", that is, technology and marketing, it is a global enterprise that creates both high added value and competitive superiority. PROMISE Technology Inc., with not only solid technological background, but with its self brand strategy, has successfully stood in the global market. Different from other Taiwan's brand name in the global market, PROMISE Technology Inc. uses a localization business operation strategy and globalization thinking, has successfully built its global sales channel and opened a global brand name without country border limitation. Its strategy emphasizes on ODM, OEM as well as brand name, it keeps a close and good contact with the global leading suppliers, it has successfully eliminated the barrier for becoming a global name to Taiwan's suppliers.

5.5 Strong global logistics, its marketing channels are well deployed.

PROMISE Technology Inc. has its business model of building global marketing sites at US (America), Holland (Europe), Mainland China (the great China area), it not only provides in time service to customer, but also successfully builds its superiority of global logistics and localization marketing. In order to fully use its localization competition superiority, PROMISE Technology Inc. has devoted to global marketing

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deployment, for example, the internationally recognized sales channels such as: Ingram Micro and Tech Data in USA, MCE in Europe, Synnex in Japan, etc., are all long term cooperation partners of PROMISE Technology Inc. PROMISE Technology Inc. also develops aggressively value-added SI/VAR distributors, for example, Avnet Applied Computing in USA, Hammer PLC in England, etc.; the result can now be seen, it is well prepared to provide customer with more complete and value-added product. Since PROMISE Technology Inc. has its relative superiority in wide deployment of global marketing channels, for example, it owns a complete localization marketing, sales, technical support, customer service, etc., therefore, it has its own market visibility of new product not only in wide scope of area, but also in its effective time-to-market.

5.6 With long term alliance relationship to international strategic partners, its customer breadth is enhanced.

Since most international storage suppliers turn their focuses to the high profit storage software market, therefore, to cope with the price lowering pressure from hardware-oriented product (for example, RAID HBA, RAID Storage) and to realize vertical integration interest, storage components are thus gradually outsourced for manufacturing or design. However, storage industry has high entrance barrier and long product life cycle, it is a technological niche market as compared to the more mature PC and Server industry, therefore, large storage supplier usually uses ODM outsourcing model to cooperate with component manufacturer, and long term alliance or contract is thus a major consideration, this is to reduce cost of ownership and enhance the quality.

Since it is a trend to use long term contract as the mutual interest warranty when storage component manufacturer cooperates with international giant supplier, PROMISE Technology Inc. has cultivated storage industry for more than a decade, with its long term customer basis, it owns obviously relative good condition and superiority. PROMISE Technology Inc. has close and long-term cooperative relationship with many international Tier 1 suppliers, from the upstream hard disc and mother board giant suppliers to downstream PC or server giant suppliers such s: Apple, Dell, Fujitsu, Fujitsu-Simens, HPQ, IBM, Intel, Maxtor, NEC, Seagate, Western Digital, etc. PROMISE Technology Inc. has grasped the industry trend and pulse for a long time, it has it own vertical integration technology, global marketing channel and after-sales service; meanwhile, plus its strict requirement on product quality, stability and compatibility, PROMISE not only becomes global leading supplier in ATA RAID, but also is the assigned cooperative target by international giant supplier, this means PROMISE Technology Inc. has built its important role and position in the international storage market.

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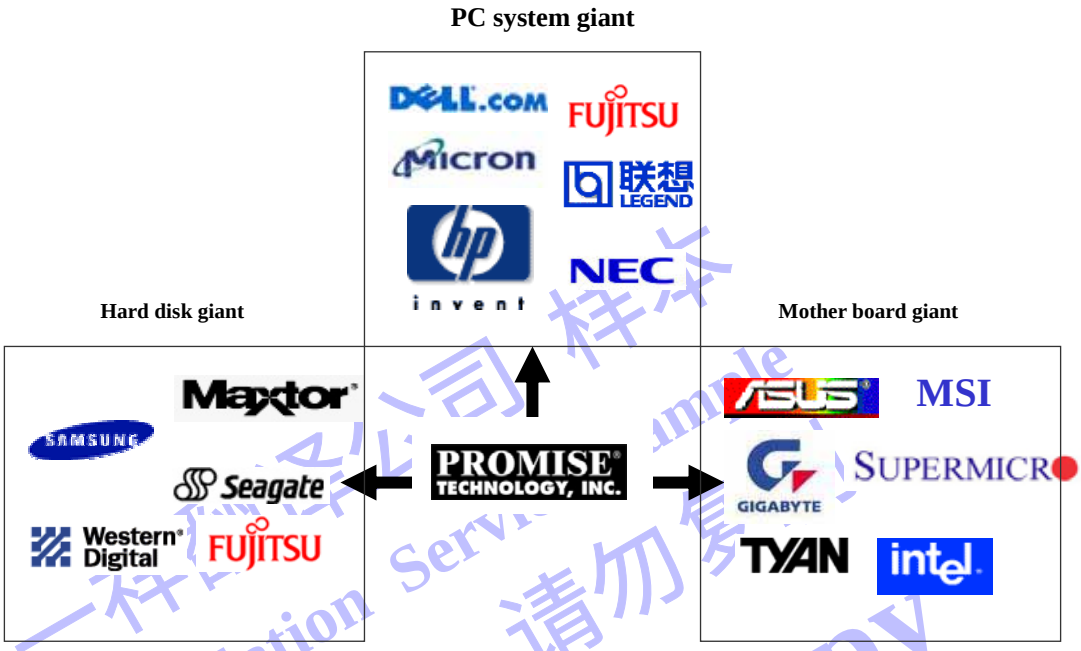

5.7 To grasp the future industry trend of Serial ATA and to lead the world in launching a complete product line for Serial ATA RAID

Serial ATA RAID has great market potential and still looks good in the future, its good price performance ratio make it seen as the mainstream storage interface in the future low and medium level market, an explosive growth is going to be seen.

In storage system market, SATA RAID covers storage architecture of DAS, NAS and SAN, more application markets are going to be covered by it (PROMISE Technology Inc. will publish them in the future), for example, to replace the position of traditional media (for example, the magnetic tape) in the storage market. In RAID HBA market aspect, Serial ATA RAID not only will replace the original ATA market within five years, but also will replace SCSI RAID HBA market; it will grow from the simple application in low level personal or enterprise market to medium and high level enterprise customer market and gradually replace SCSI RAID HBA in DAS market.

PROMISE Technology Inc. has grasped storage spec and industry pulse for a long time, it leads the market to announce a complete series of Serial ATA RAID storage in Computex last year, ranging from SATA RAID 0/1 solution: FastTrak S150 TX2plus (2 SATA port plus one ATA port), FastTrak S150 TX4 (4 SATA ports) to SATA RAID 5 solution (4 SATA ports); its product has been adopted by international giant supplier one after another due to its capability to launch new product in time, the performance of the product becomes clearer. This fully shows that PROMISE Technology Inc. can see clearly and deeply the future industry trend and grasp it so as to stand at the leading position of the business.

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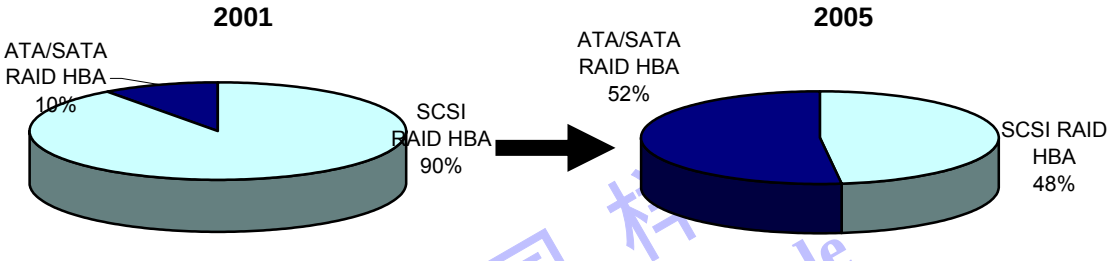
SATA RAID HBA will gradually replace the medium level market role played by SCSI RAID HBA



Source: Host-based RAID Controller Worldwide Market Share and Forecast, 2001, Dataquest

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